2005

Track, Engage, & Neutralize Threats Asymmetric & Conventional in the Littoral Environment

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Track, Engage, & Neutralize Threats – Asymmetric & Conventional – in the Littoral Environment

TSSE Team

Faculty

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2005 Student Design Team

Payload

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Combat Systems

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3 Countries

4 Academic Curricula

Agenda

- Overall Design Process
  - Requirements Analysis
  - Functional Analysis Allocation
- Payload and Operational Concept
- Combat Systems
- Hull, Mechanical, and Electrical (HM&E)
- Summary

The Classical Systems Engineering Process

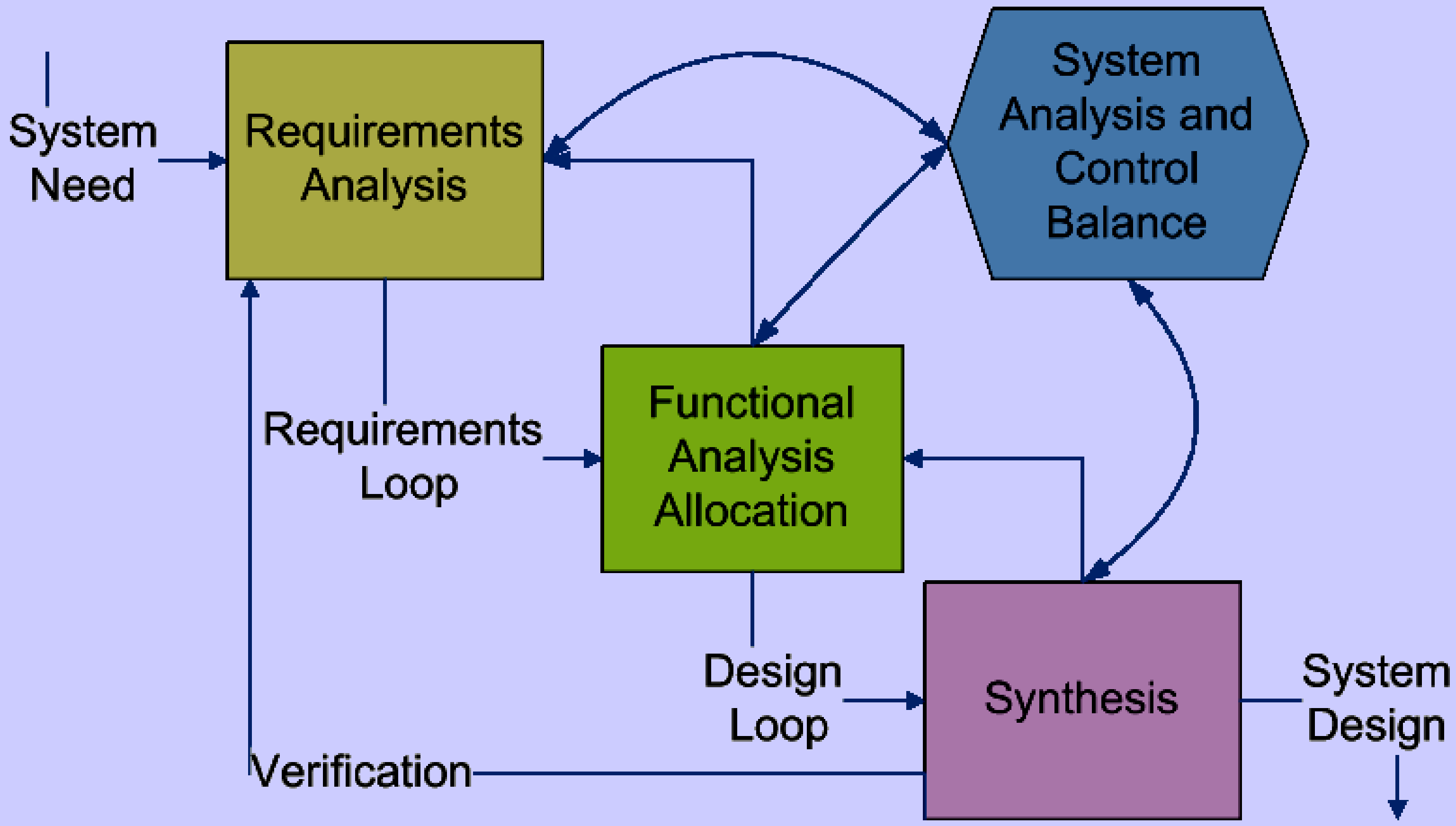
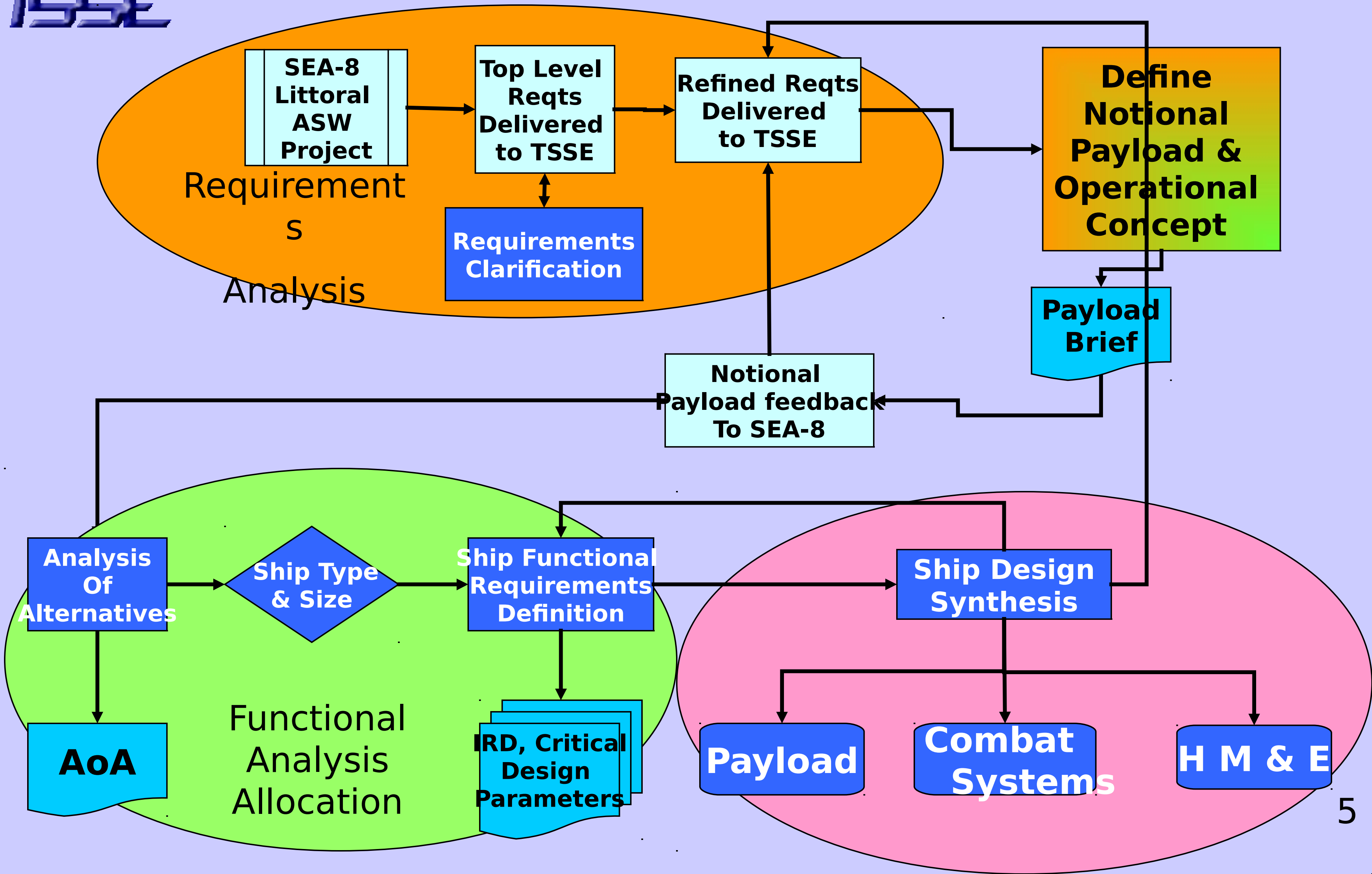


Figure from NAVSEA Ship Design Manager (SDM) Manual

TSSE Tailored Systems Engineering Design Process



Top Level Requirements

Deploy

Prepare system components | Deliver system components | Sustain system components

- **Deploy, retrieve, and regenerate large UUVs semi-clandestinely**
- **Sensor assets required to provide Pd 0.8 across contested OA (6,700 NM2) within 10 days**
- **Provide logistic support necessary to sustain SoS for 30 days**
- **Communicate on the following circuits:**

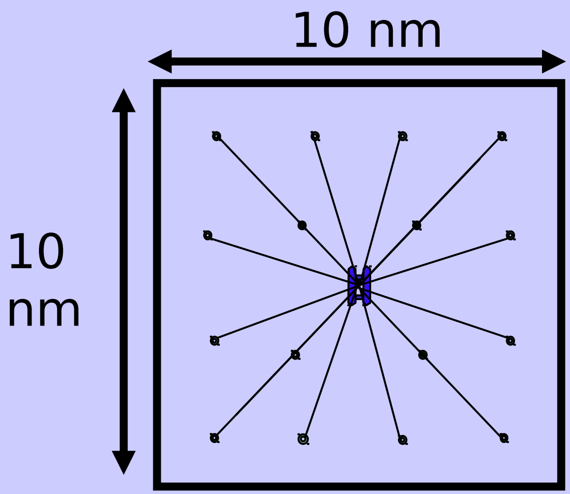
  High Band Width Air/Space Line of Sight (LOS) **LOS Data**

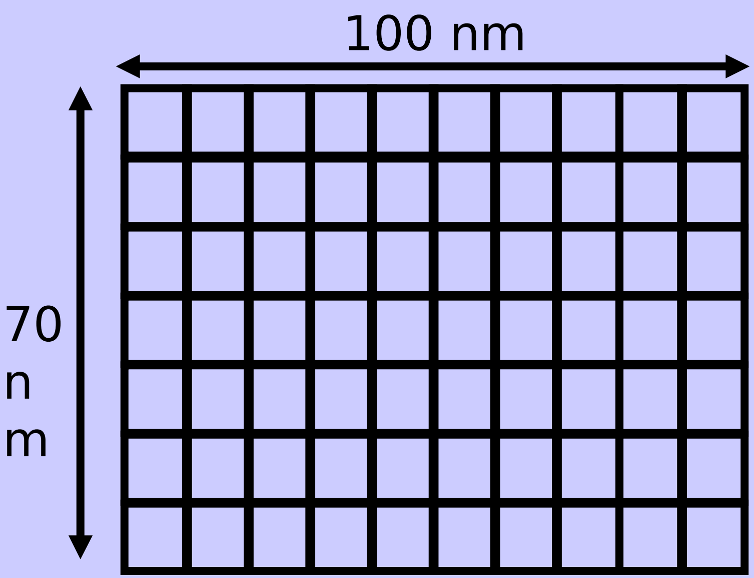
  LOS Voice **OTH Data**

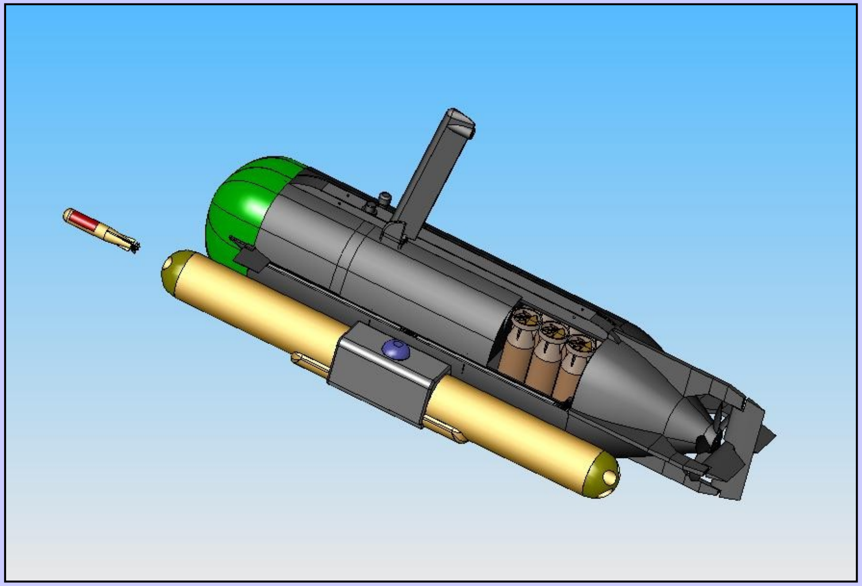
  OTH Voice **SATCOM**

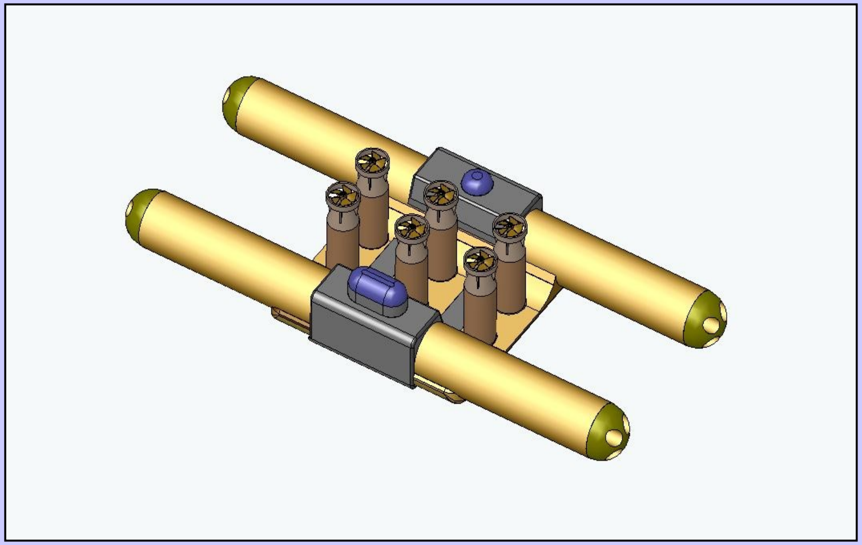
  Underwater Data
- **Launch, recover, and control a 7,000 lb UAV**
- **Deploy box-launcher weapons and torpedoes for enemy engagement**

Notional Payload and Operational Concept









Top Level Analysis of Alternatives (AoA)

- Conducted from Aug-Sep using notional payload architecture and SEA-8 scenario

- Competing Architectures:

  -- LCAC size craft (single and wave) -- Mid-size ship

  -- LCS Module (single and wave)

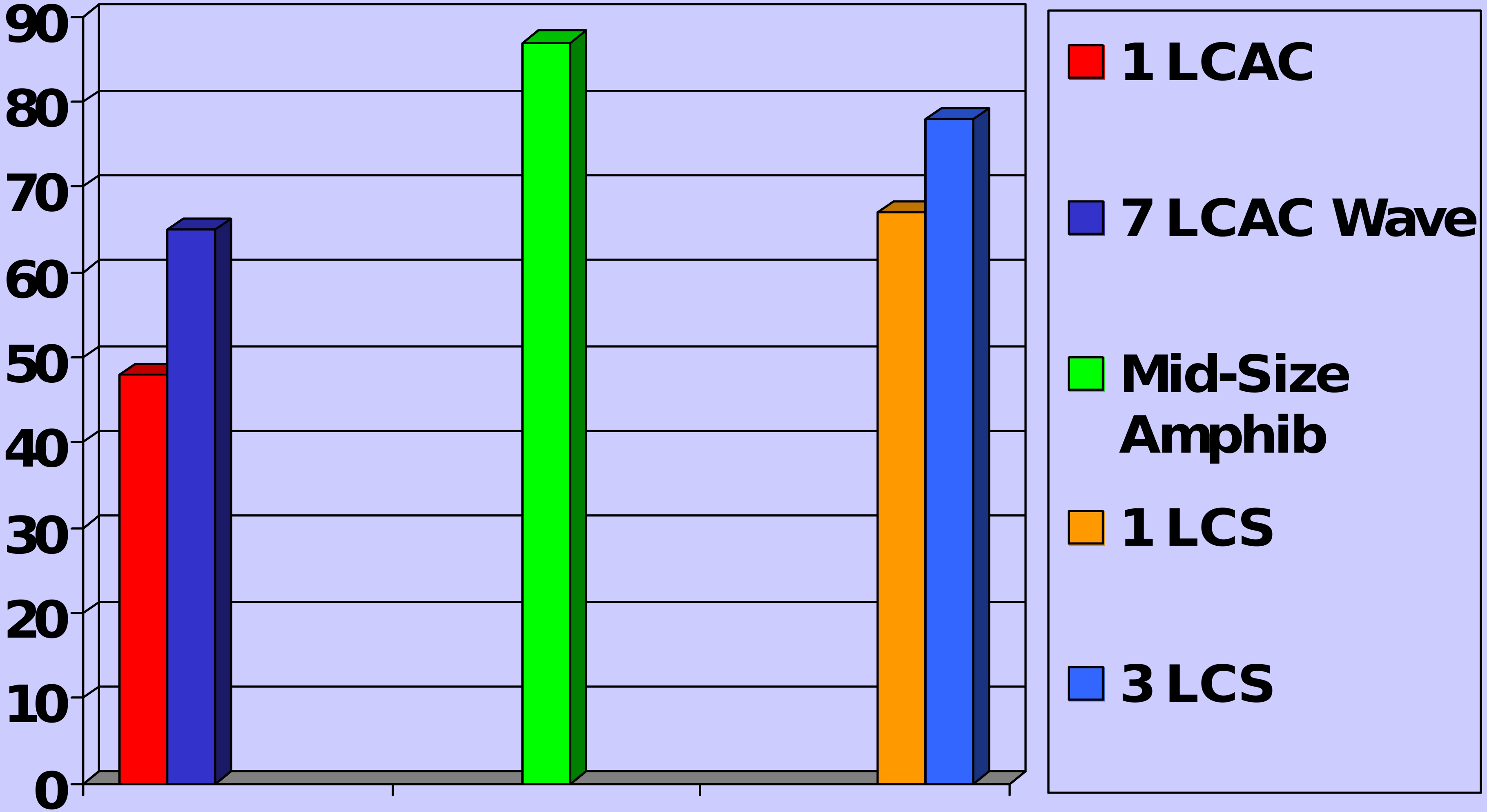
- Selection Criteria:

  -- Capability (30) -- Deployability (20) -- Survivability (20)

  -- Endurance (10) -- Flexibility (10) -- Technical Risk (5)

  -- Cost (5)

Top Level AoA Results



Critical Design Parameters

TSSE

Category	Threshold	Objective
Operational Availability	0.85	0.95
Hull Service Life	20 years	30 years
Draft @ Full Load	8 m	5 m
Max Speed	30 + kts	40 + kts
Range @ Max Speed	1000 nm	1500 nm
Range @ Cruise Speed	3500 nm	4500 nm
Large UUV Capacity	40	50+
Hvy Wt UUV capacity	80	100+
Cargo Weight	400 MT	800 MT
Cargo Volume	5000 m^3	6000 m^3
Small Boat (7 m RHIB)	1	2
USV (11 m RHIB)	1	2
UUV/USV/UAV Launch Recover	Sea State 3	Sea State 4
Aviation Support	One 7000 lb VTUAV	VTUAV (2)/ SH-60R
Aircraft Launch / Recover	VTUAV	VTUAV/SH-60R
UNREP MODES	RAS, CONREP, VERTREP	RAS, CONREP, VERTREP
Core Crew Size	≤130	≤100
Crew Accommodations	125	125
Provisions	30 days	45 days

Agenda

- ✓ Introduction and Overall Design Process
- Payload and Operational Concept
  - Components
  - Launch, Deployment, and Recovery
  - Handling Systems
  - Payload Modeling
- Combat Systems
- Hull, Mechanical, and Electrical (HM&E)
- Summary

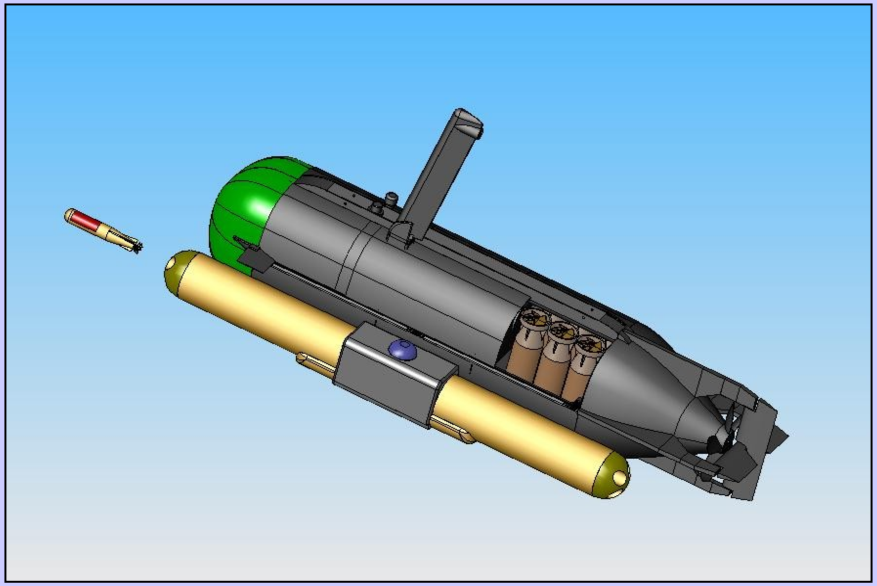
Notional Architecture

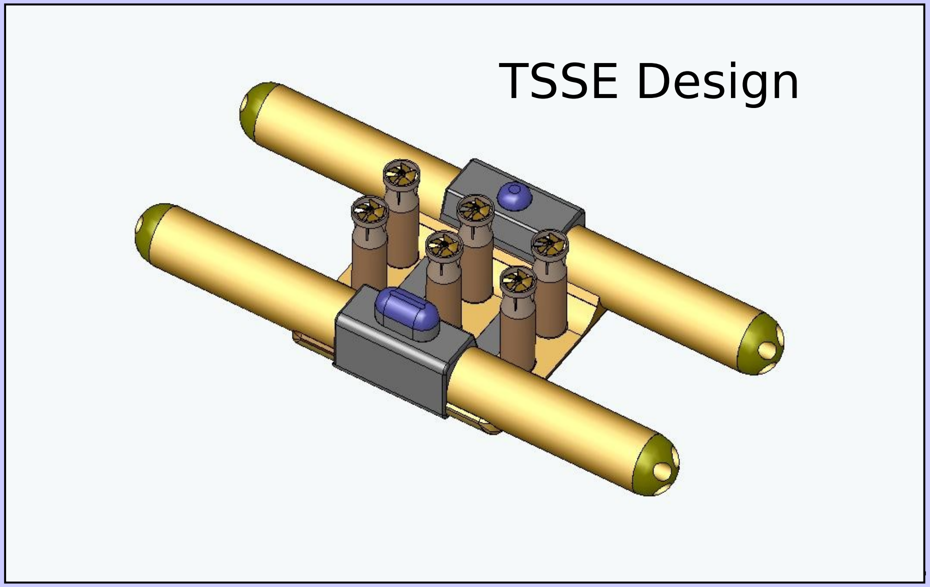
Challenge	Response
Contested air space	Covert insertion and recovery, 200nm standoff range
30 day sustained operations	Centralized hub replenishment and recovery
Time and Space: 100 nm^2 in 72 hrs 6700 nm^2 in 10 days	Single launch cycle followed by ongoing service cycles

10 nm X 10 nm Network Hub

Architecture Refinement with TSSE/SEA-8 Collaboration

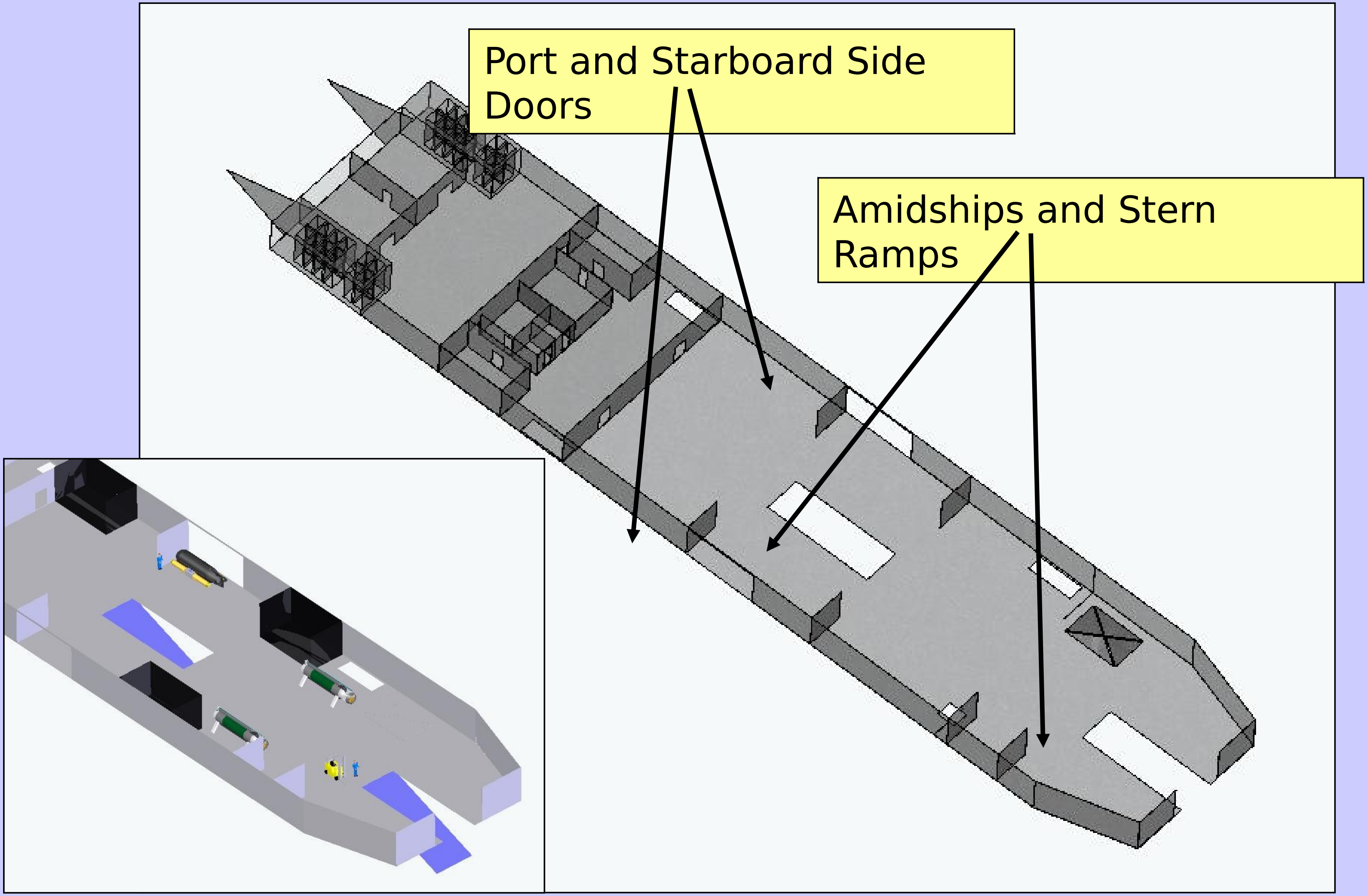
- 1 Large UUV (*Sea Predator)
- 1 Sled equipped with deployable RF buoy, acoustic modem, docking transducers, coupling two 21” diameter shapes
- 6 Light Weight UUVs – four for power, two for sensor processing and communications control
- 16 man-portable sensor and wire deployment vehicles





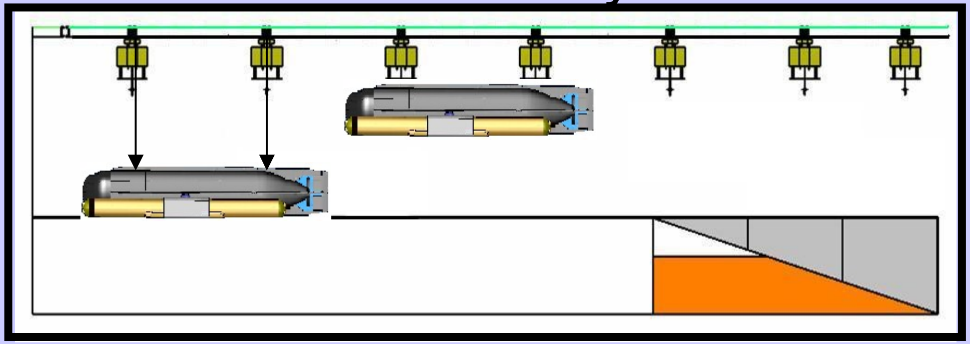
* Sea Predator, David DeMartino, NAVSEA Panama City

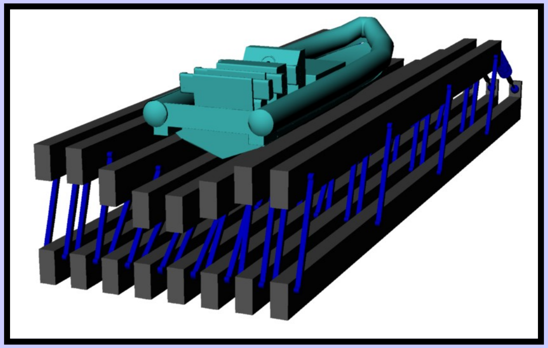
Payload Deck



Handling Systems

- X-Y-Z Overhead Hoist Array and Deck-rail Storage System
  - Longitudinal overhead monorail along centerline
  - Transverse overhead rail pairs
  - Reconfigurable two tier shelves anchored into deck rails provide secure stowage
  - Port and Starboard amidships rail extensions provide over the side lift capabilities
  - Amidships ramp cradle handles up to Large UUV’s
  - Stern ramp variable geometry cradle for larger capacity launch and recovery





Notional Architecture

2025 Notional Sensor Coverage

ASSUMPTIONS:

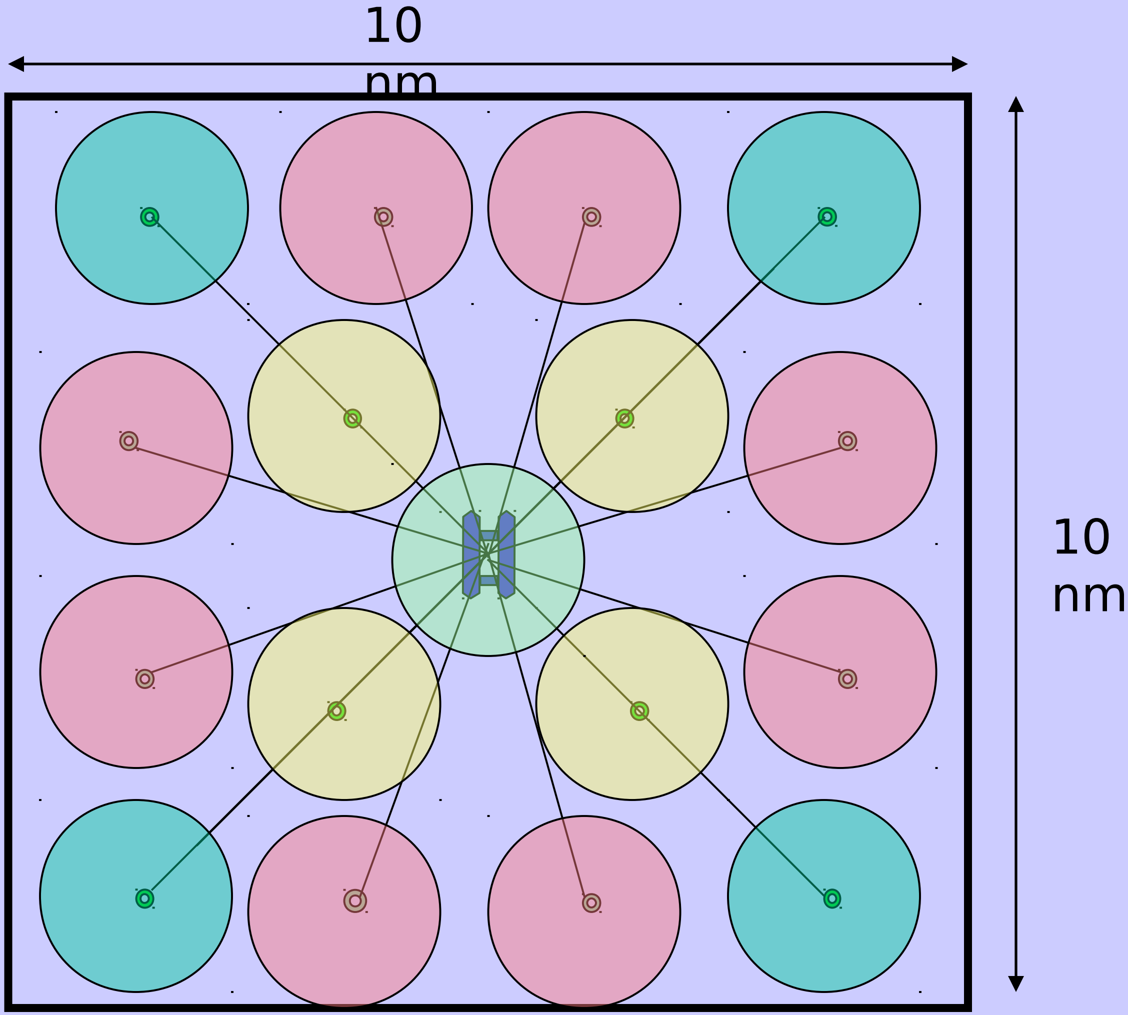
-**1 nm Detection Radii**

-**Sensor Spacing:**
4 nodes at 5nm

8 nodes at 4nm

4 nodes at 2nm

1 center node



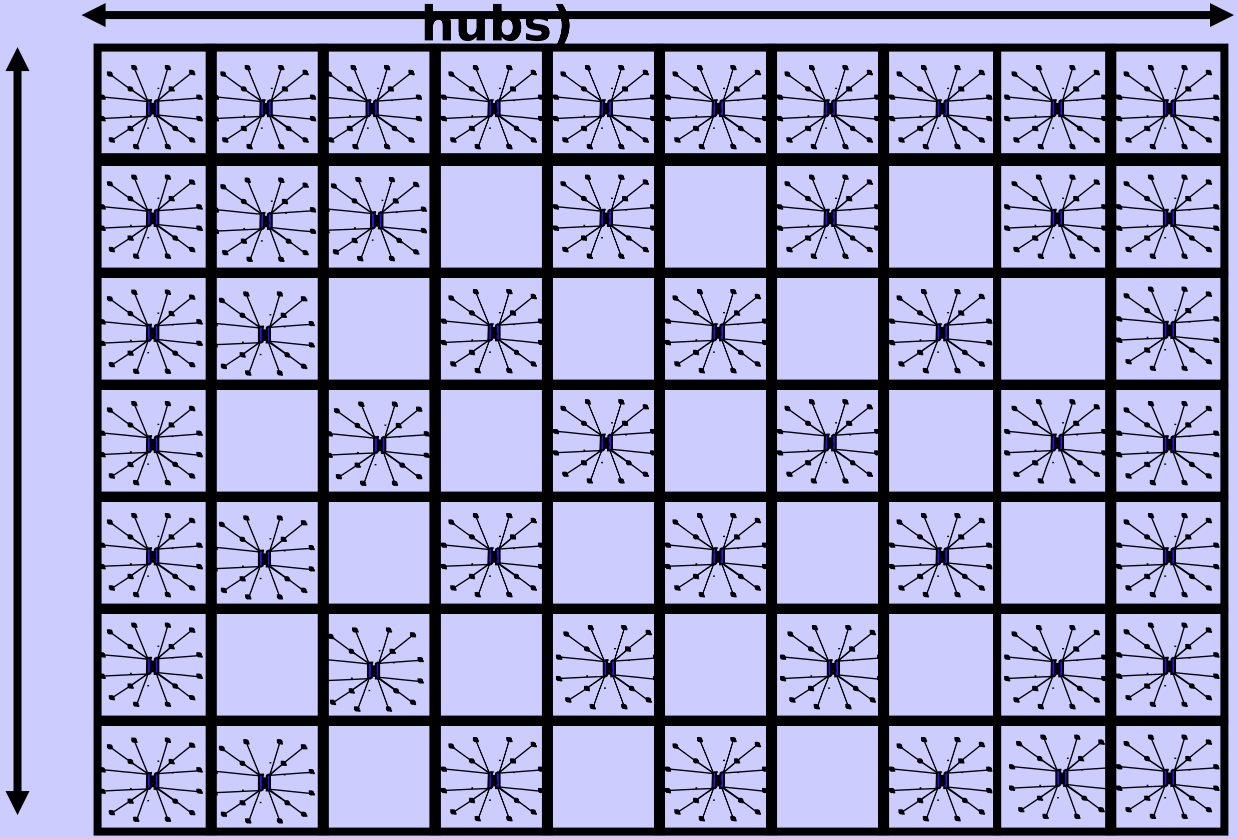
Maximum Capacity: 48 fixed hubs + 48 mobile Sea Predators

Top Level Requirement: Full AO Coverage

100 nm (10 hubs)

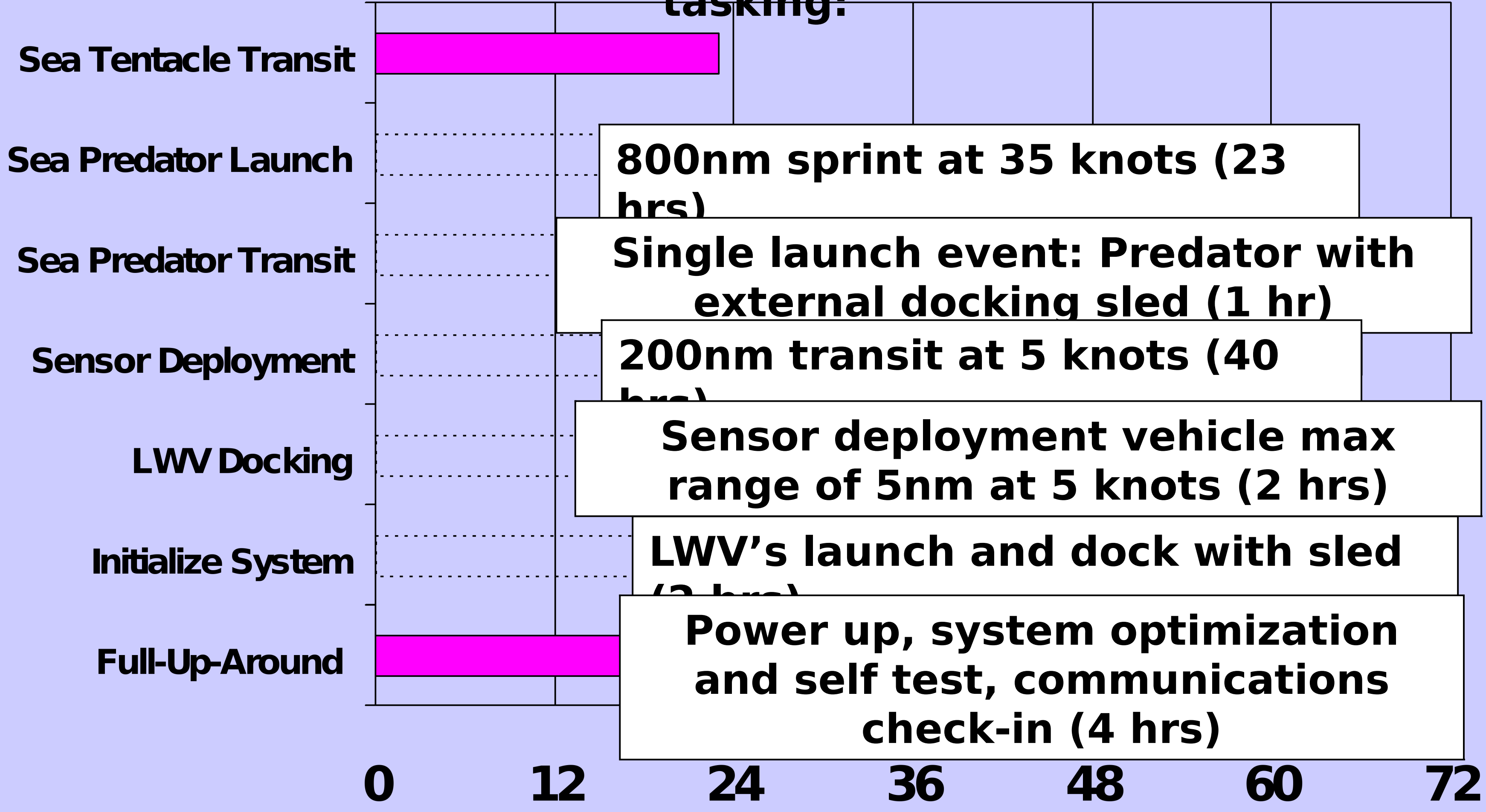
70 nm

(7 hubs)



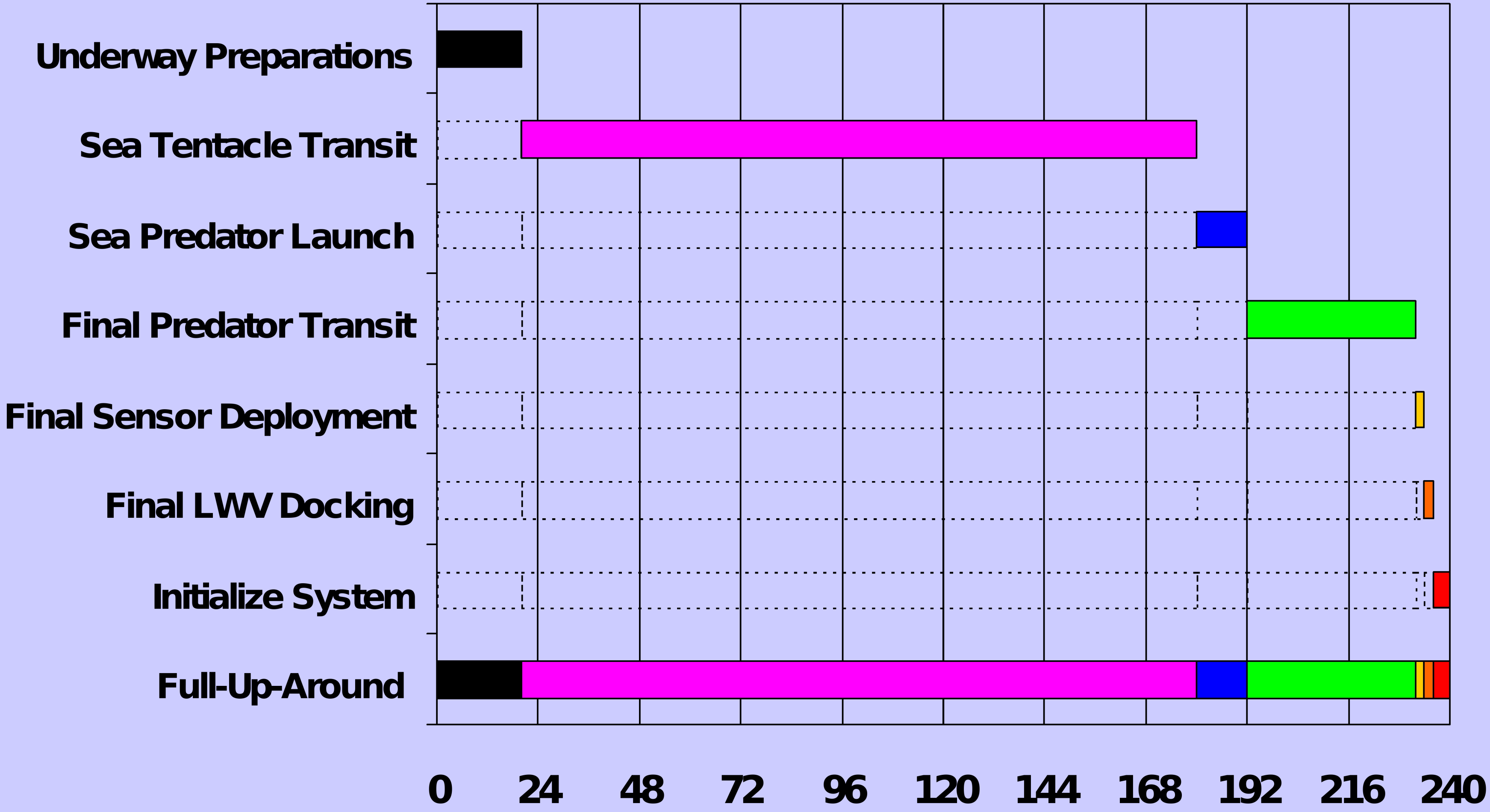
72 Hour Single Hub Deployment Mission Range: 1000nm

Loitering at 1,000nm from the Harbor Gate AO, Sea Tentacle receives urgent tasking:



10-Day Maximum Payload Deployment
Mission Range: 3,400nm

In port at < 24 underway readiness, Sea Tentacle receives urgent tasking to AO at 3,400nm range:

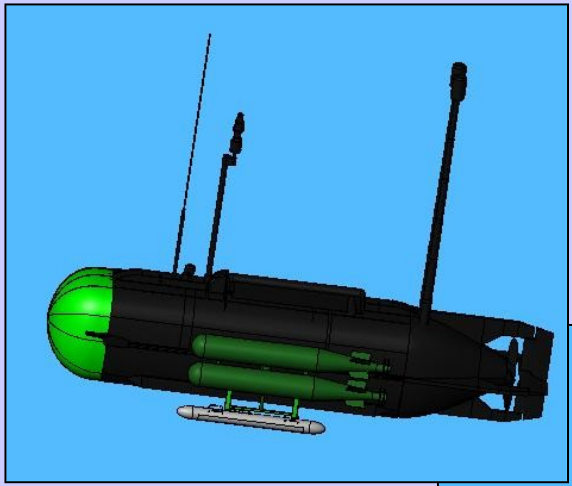


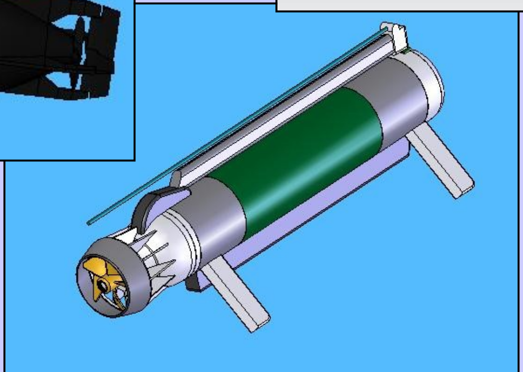
UUV Network Applications

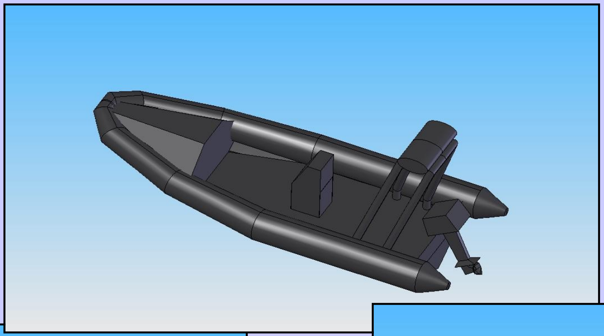
- Perimeter defense of <u>Sea Base</u> and high value transit lanes
- Core ASW and MIW capabilities providing offensive and defensive early warning envisioned by <u>Sea Shield</u>
- Wide area battle-space preparation and intelligence gathering capabilities for time critical <u>Sea Strike</u>

Mission Payload

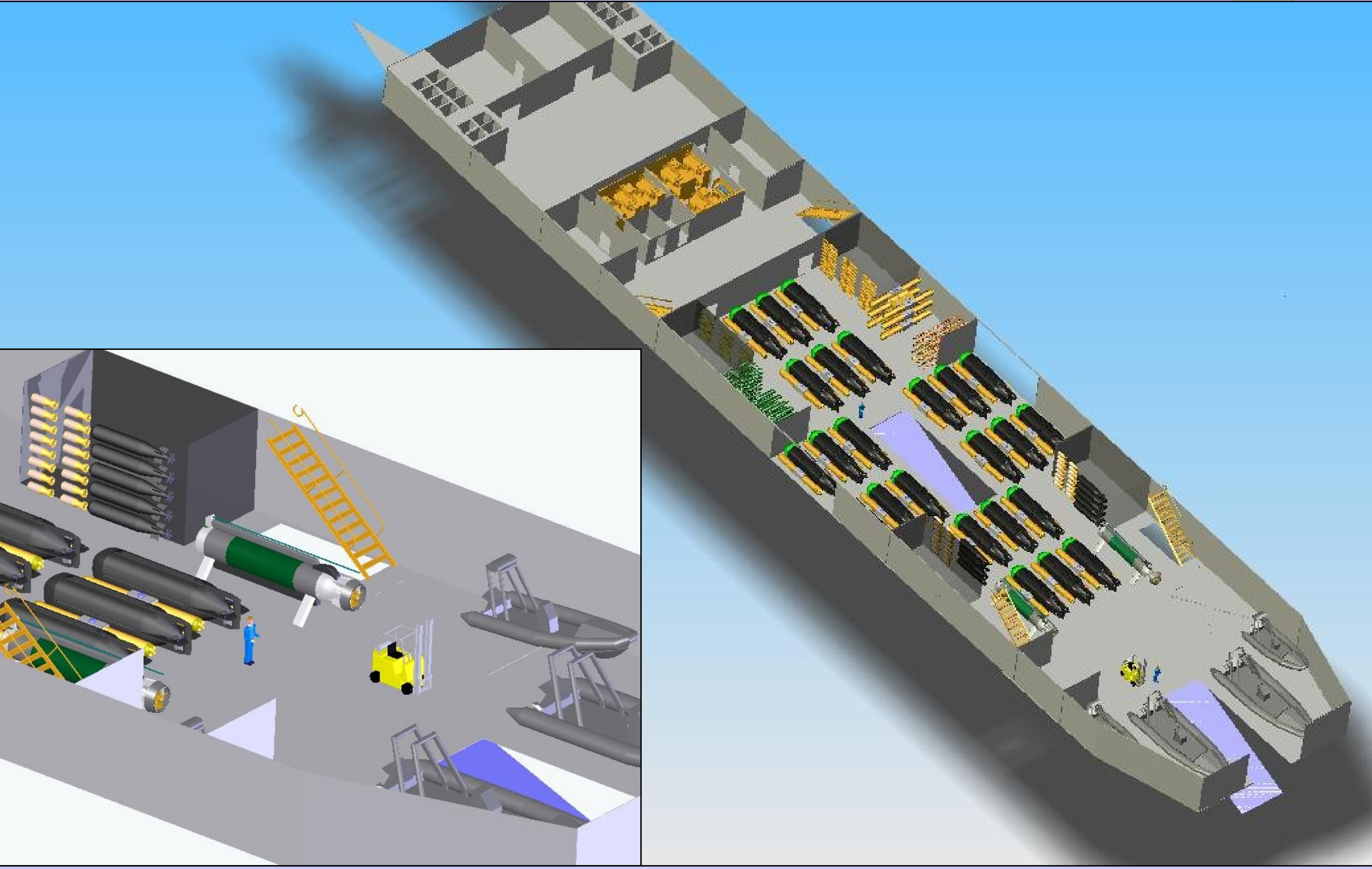
Baseline Operational Unit Count					
Sea Predator (Large UUV)	AN/WLD-1 (Large UUV)	11m RHIB (USV equipped)	7m RHIB	SH-60R	VTUAV
48	2	2	2	2	2







Detailed Payload Deck-Plan



Payload Top Level Requirements

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- **Deliver system components**
- **Sustain system components**

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  LOS Voice **OTH Data**

  OTH Voice **SATCOM**

  Underwater Data

- **Launch, recover, and control a 7,000 lb UAV**
- **Deploy box-launcher weapons and torpedoes for enemy engagement**

Agenda

- ✓ Introduction and Overall Design Process
- ✓ Payload and Operational Concept
- **Combat Systems**
  - **Derived Requirements**
    - **Weapons Deployment**
    - **Communications**
  - **Design Philosophy**
  - **ICMS Architecture**
  - **Component Selection**
    - **Layered Defense**
    - **Radio Frequency Systems**
  - **Radar Cross Section Analysis**
  - **Summary**
- Hull, Mechanical, and Electrical (HM&E)
- Summary

Threat Matrix

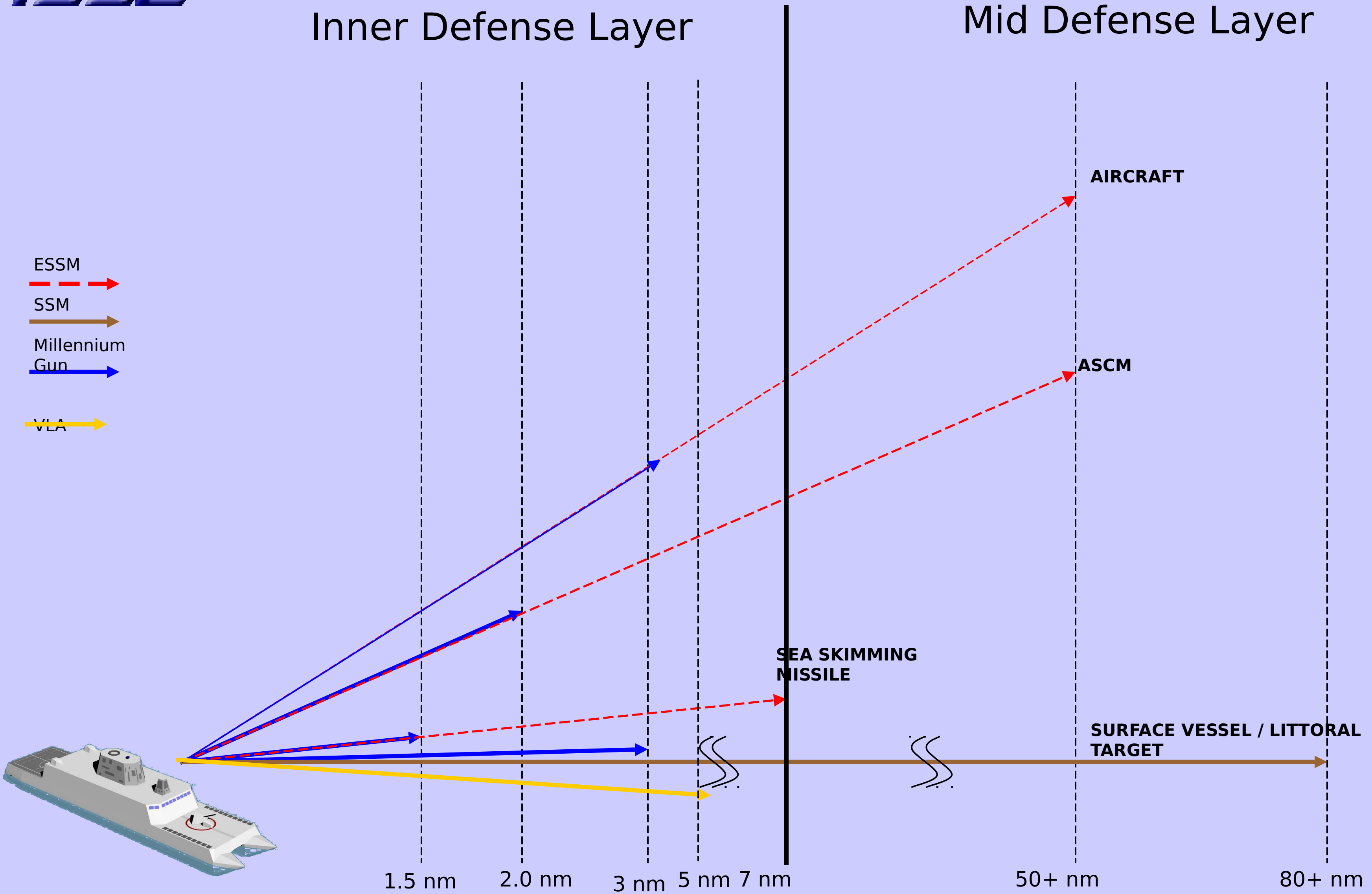
Threat	AMRFS	TISS	EW Suite	ISMD/A	ASROC	ESSM	SSM	Millenium Gun
ASCM	D	D	D - SK			HK		HK
Aircraft	D	D	D			HK		HK
Ship	D	D	D	D		HK *	HK	HK
Submarine				D	HK			
Small boats	D	D	D	D			HK	HK
Mines				D				HK
Shore Fire		D	D				HK	HK

← SENSORS → ← WEAPONS →

D – Detection SK – Soft Kill HK – Hard Kill

HK* - Anti-ship ESSM requires software upgrade

Defense in Depth



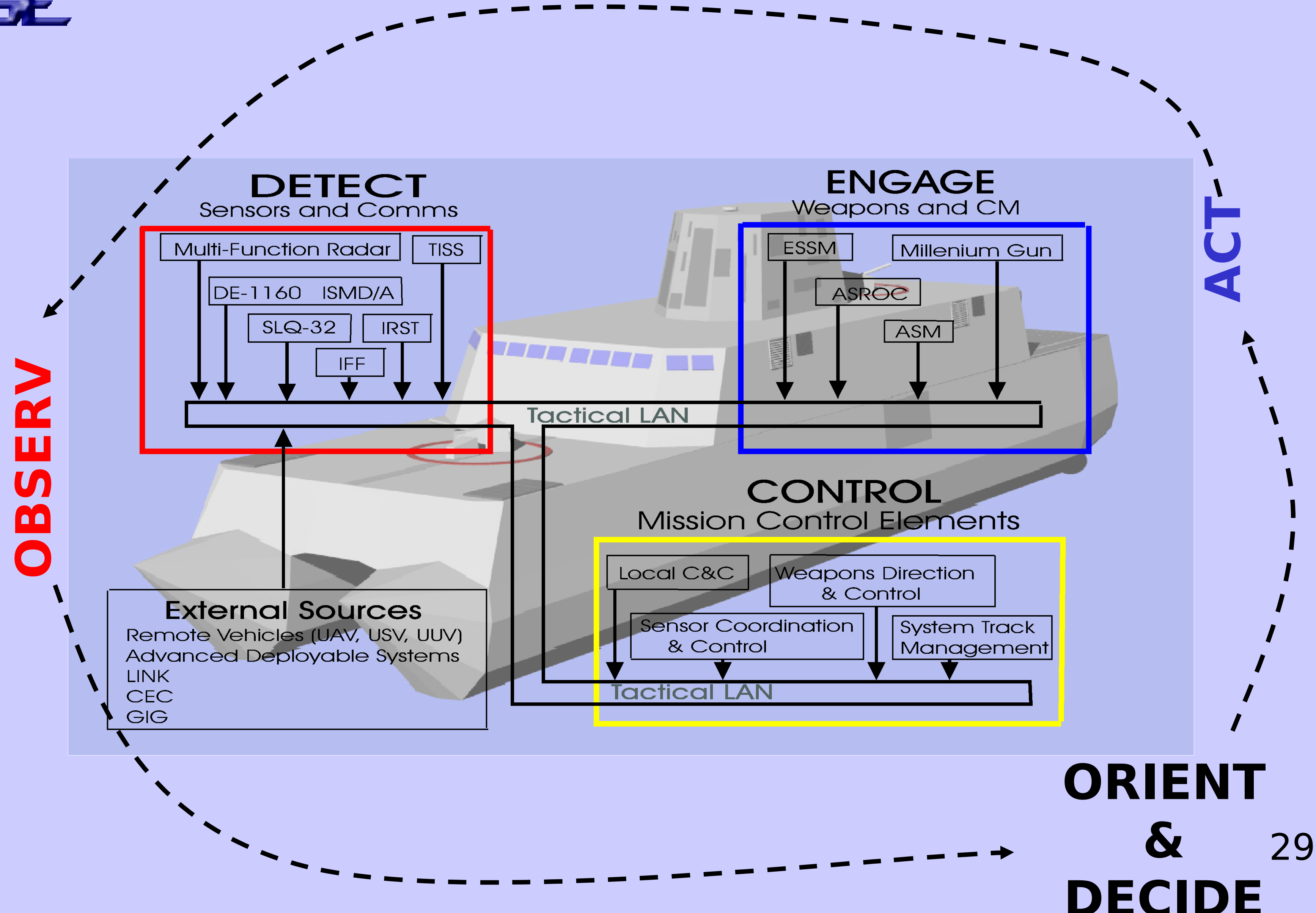
External Communications

RF External Communications

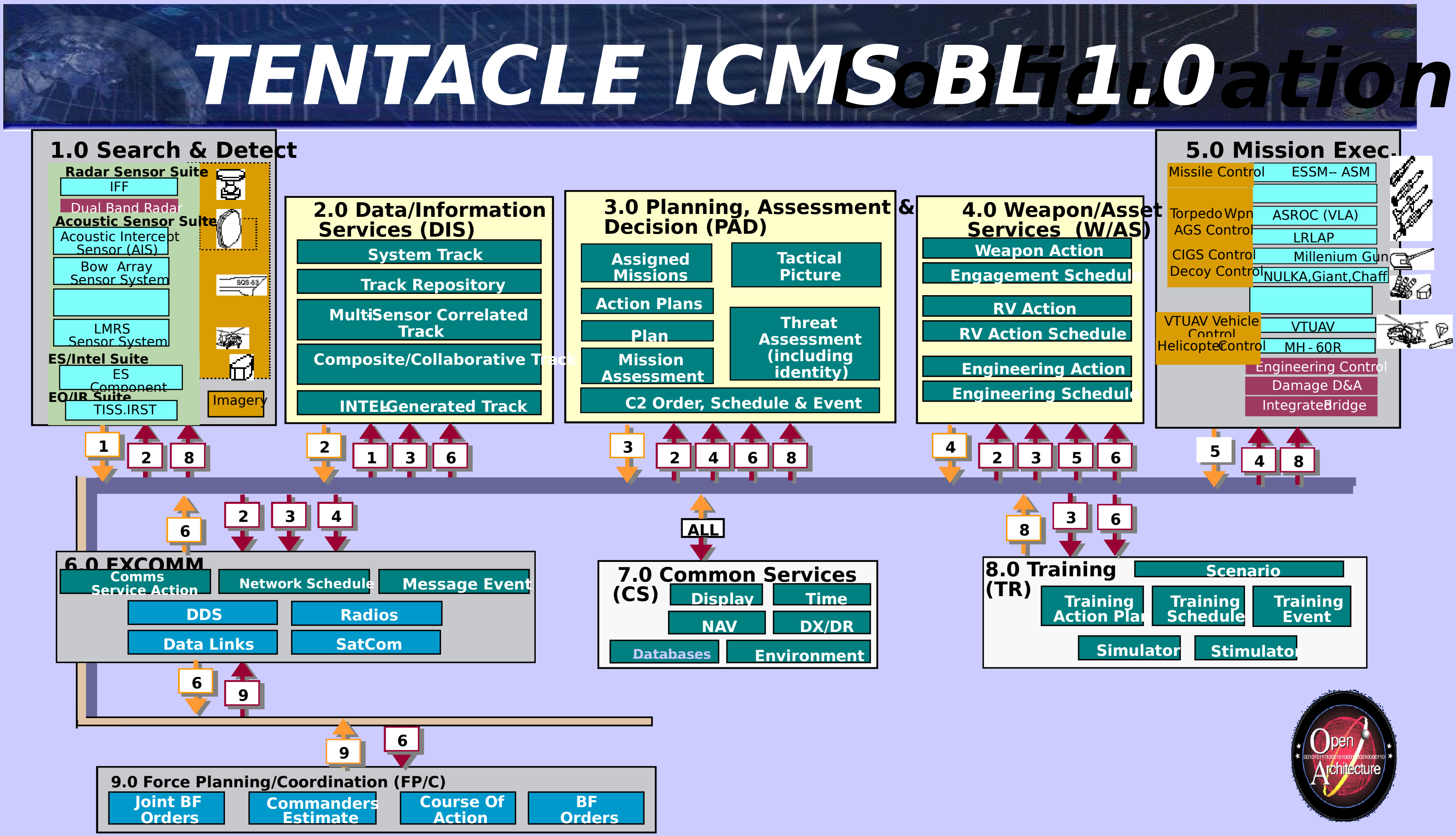
- The ship will be fully interoperable with the following systems:
  - **CEC**
  - **Joint Planning Network**
  - **Joint Data Network**
  - **GCCS-M**
  - **SIPRNET**
  - **NIPRNET**
- The following frequency ranges / data rates will be supported:

- UHF SATCOM	**512 – 4.5 Mbps**
- SHF SATCOM	**1.544 Mbps (T-1) – 45 Mbps (T-3)**
- UHF LOS	**200 kbps**

Integrated Combat Management System



ICMS Open Architecture Design



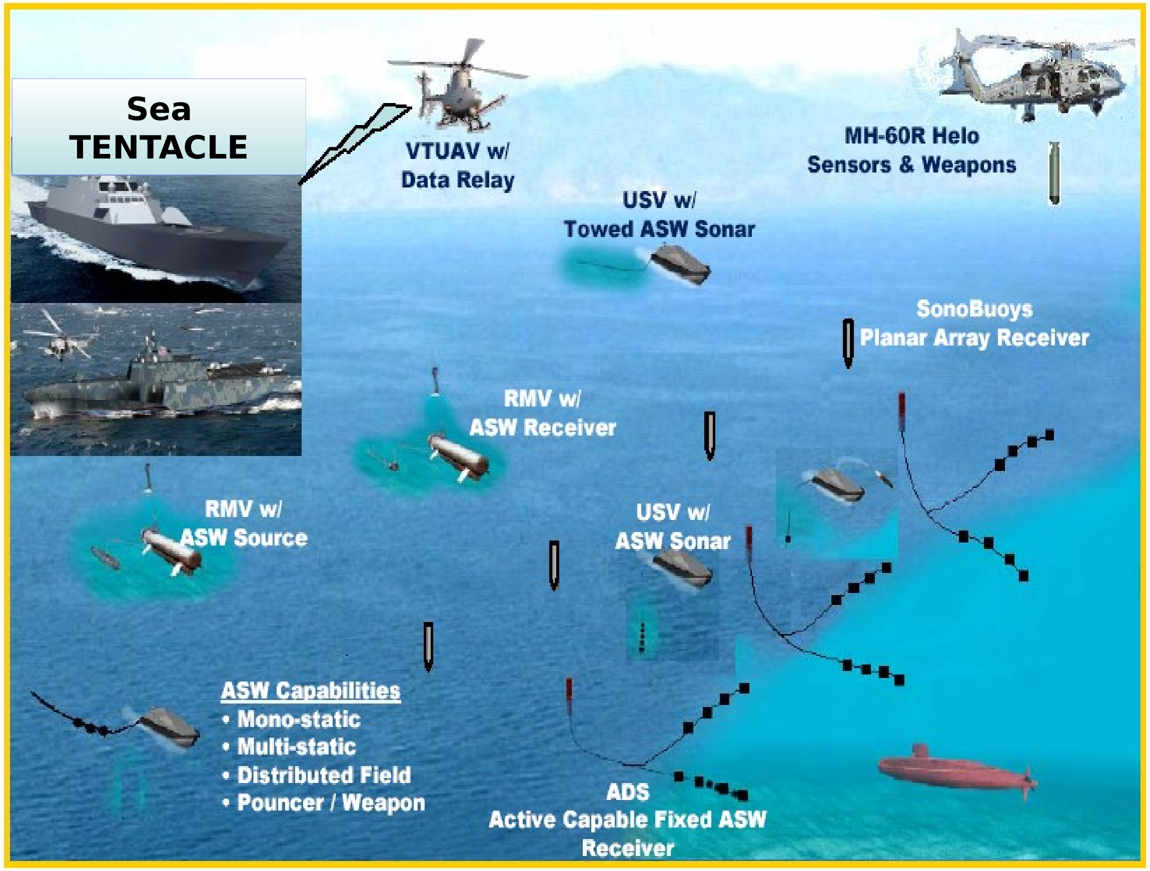
Mission Areas

<u>Operating Characteristics:</u>

- Net-Centric
- Collaborative
- Distributed Functionality
- Strong HSI Focus

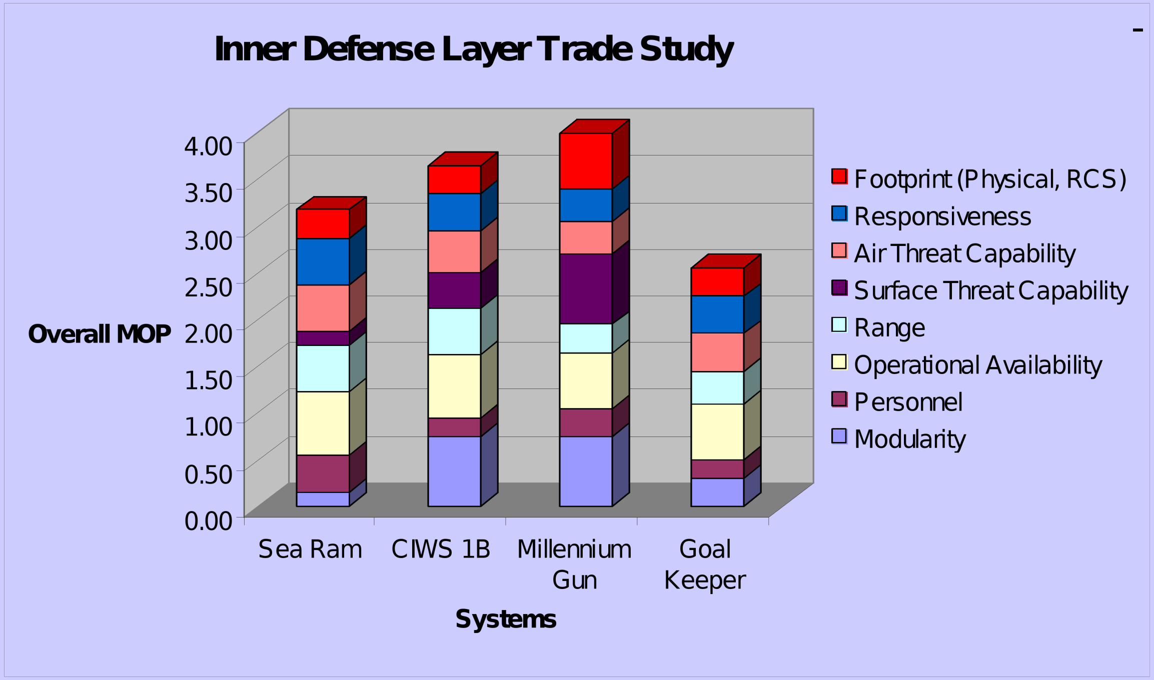
<u>Mission Areas:</u>

- Littoral ASW/MIW
- SUW (Maritime Surveillance)
- AAW



Inner Defense Layer AoA

Design Requirements	Weight	Sea Ram	CIWS 1B	Millennium Gun	Goal Keeper
Modularity	0.15	1.00	5.00	5.00	2.00
Personnel	0.10	4.00	2.00	3.00	2.00
Operational Availability	0.15	4.50	4.50	4.00	4.00
Range	0.10	5.00	5.00	3.00	3.50
Surface Threat Capability	0.15	1.00	2.50	5.00	0.00
Air Threat Capability	0.10	5.00	4.50	3.50	4.00
Responsiveness	0.10	5.00	4.00	3.50	4.00
Footprint (Physical, RCS)	0.15	2.00	2.00	4.00	2.00
Totals	1.00	0.64	0.73	**0.80**	0.51



<u>Selected System:</u>

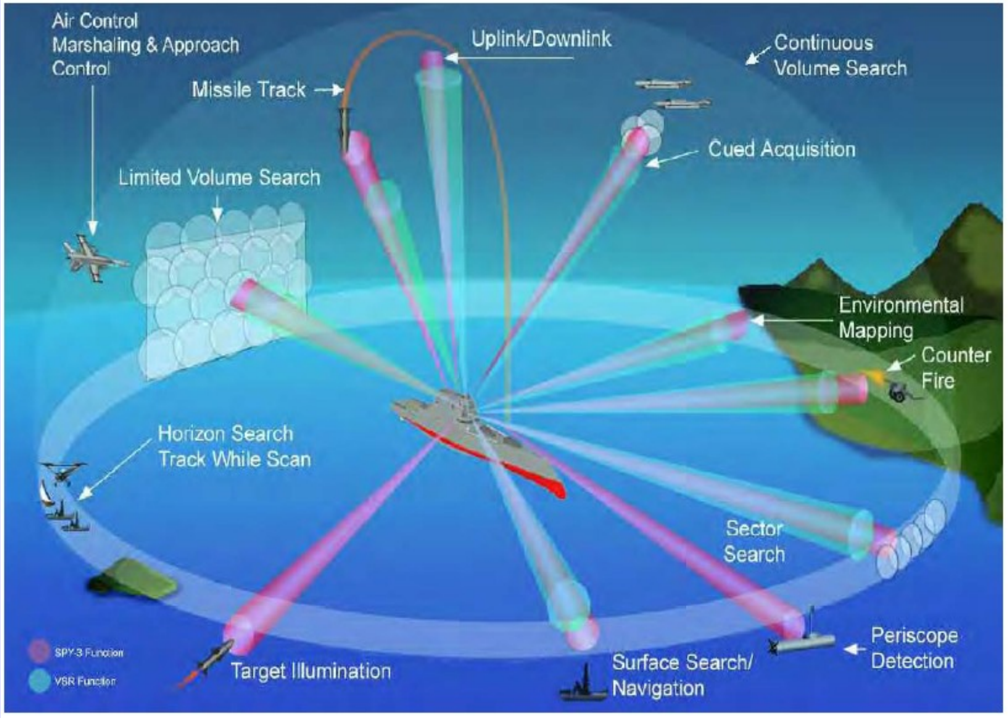
Millennium Gun

- Range (air): 3.5 nm
- Range (cruise missiles) : 1.08 nm
- Range (sea-skimming missiles): 0.8 nm
- Firing Rate: 1,000 rounds/min
- 152 sub-projectiles per round

Advanced Multifunction RF System (AMRFS) Capabilities

Multi-functional:

- Communications
  - Satellite Communications
  - Line-of-Sight Communications
- Electronic Attack (EA)
  - Noise Jamming
  - Deceptive Jamming
- Electronic Surveillance (ES)
- Radar
  - Surface Navigation Radar
  - Volume Search
- Reduced Maintenance
  - Array & Subsystem Calibration, Characterization, and Diagnostics



Source: Raytheon DBR

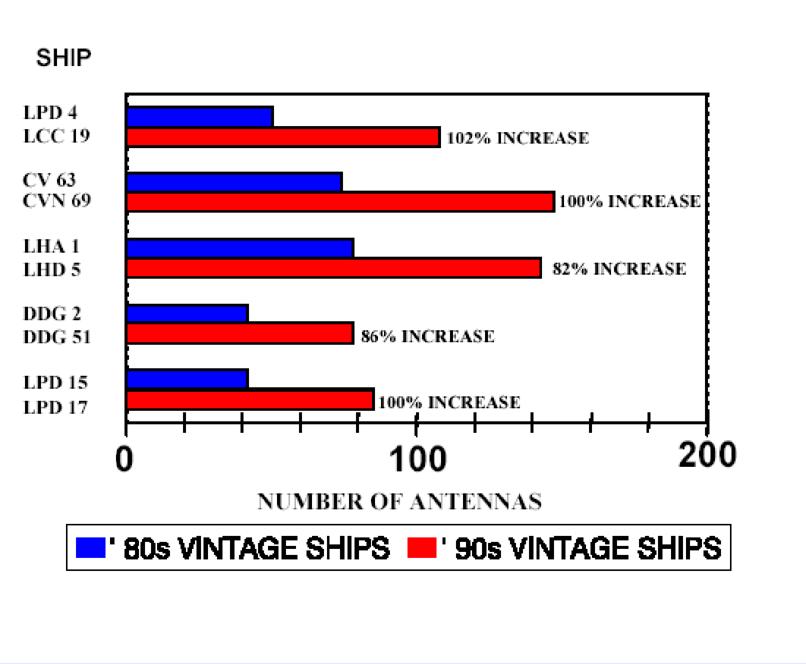
AMRFS Motivation

Benefits:

- Reduces Total Number of Required Topside Arrays
- Increases Potential for Future Growth without Major Ship Alterations
- Tighter Control over EMI/EMC Issues
- Functionality Primarily Defined by Software
- Potential for Substantial Reduction in Life Cycle Costs
- Enables Reallocation of RF Functions

Summary:

- RF functions can be customized to tactical environment, enhancing war-fighting capabilities !!!



W. Gottwald, “An Overview of the Advance Multifunction RF Concept (AMRFC) Test-Bed”, 04APR14

Radar Cross Section (RCS) Estimation

- For our design RCS estimation, we used two techniques:
  - Empirical Method (Skolnik)
  - Physical Optics Method (POFACETS Software)

Empirical Method of RCS Estimation

- Skolnik (1980) suggested a formula to estimate the median RCS of a ship based on its displacement and the frequency of operation of a given seeker:

$$\boxed{\sigma_{\mathrm{m}^2} = 1644 \times \sqrt{D_{\mathrm{kT}}^{\ 3} \times f_{\mathrm{GHz}}}}$$

- For our design, with a displacement of around 7000 LT and a frequency of operation of 0.3 GHz:

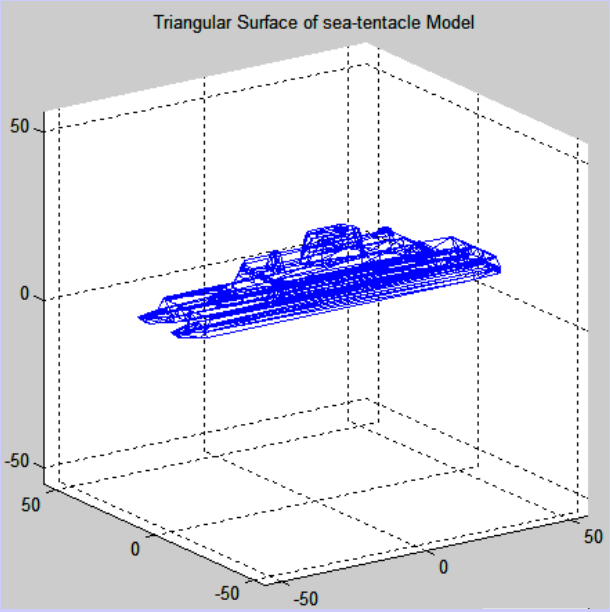
$$\sigma_{\text{Sea-Tentacle}} = 16677\ \mathrm{m}^2 = \boxed{42\ \mathrm{dBsm}}$$

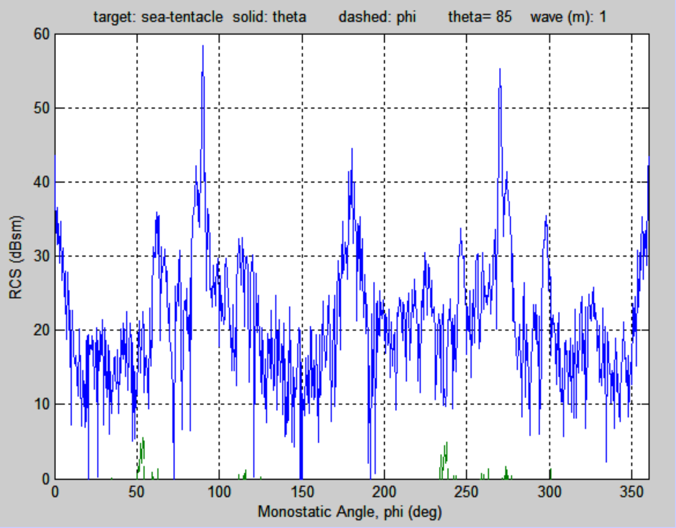
- This approximation varies with the angle. 13 dB (for broadside) are added and 8 dB (for minima) are subtracted.

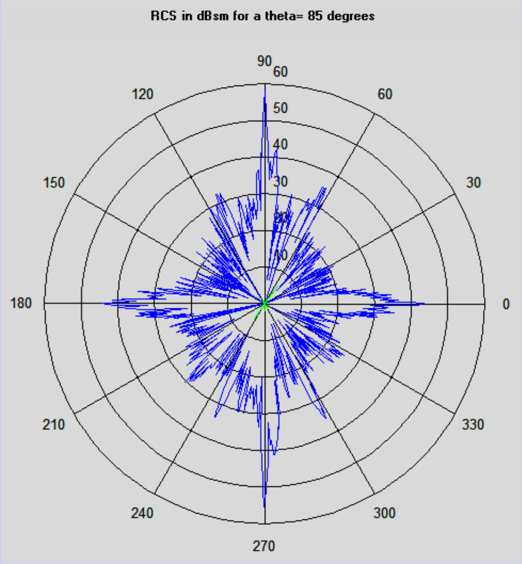
$$34\ \mathrm{dBsm} \le \sigma_{\text{Sea-Tentacle}} \le 55\ \mathrm{dBsm}$$

Physical Optics Method of RCS Estimation

- POFACETS is a RCS tool developed by Dr. Jenn of the ECE Dept. of NPS.
- It is based on the Physical Optics Method.
- Ship Parameters used by POFACETS were generated with RHINO software.



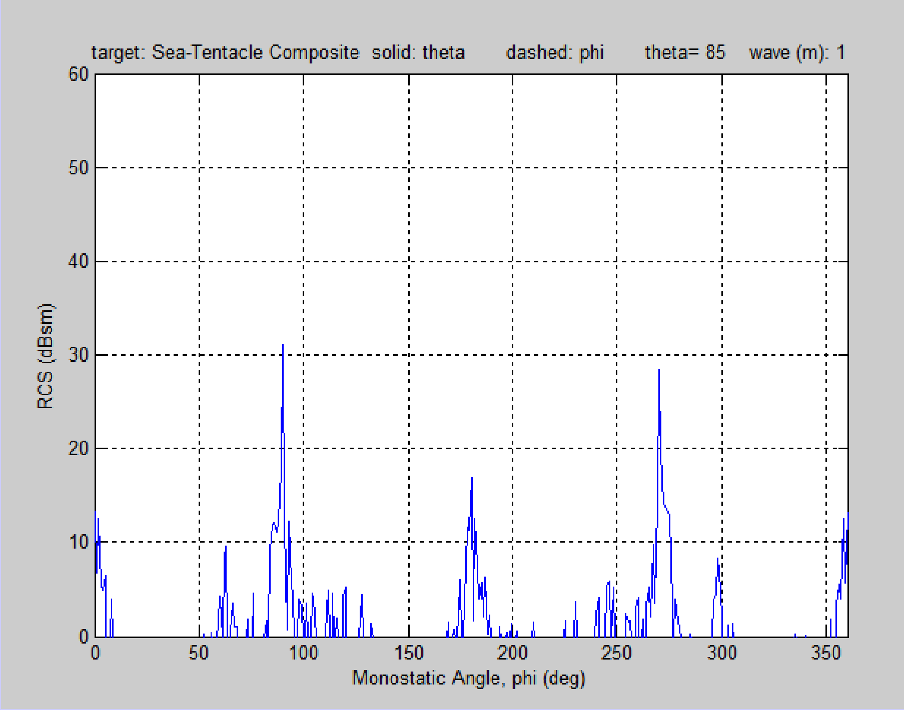




RCS Results using a PEC material model at a frequency of 0.3 GHz

RCS as a Function of Material Selection

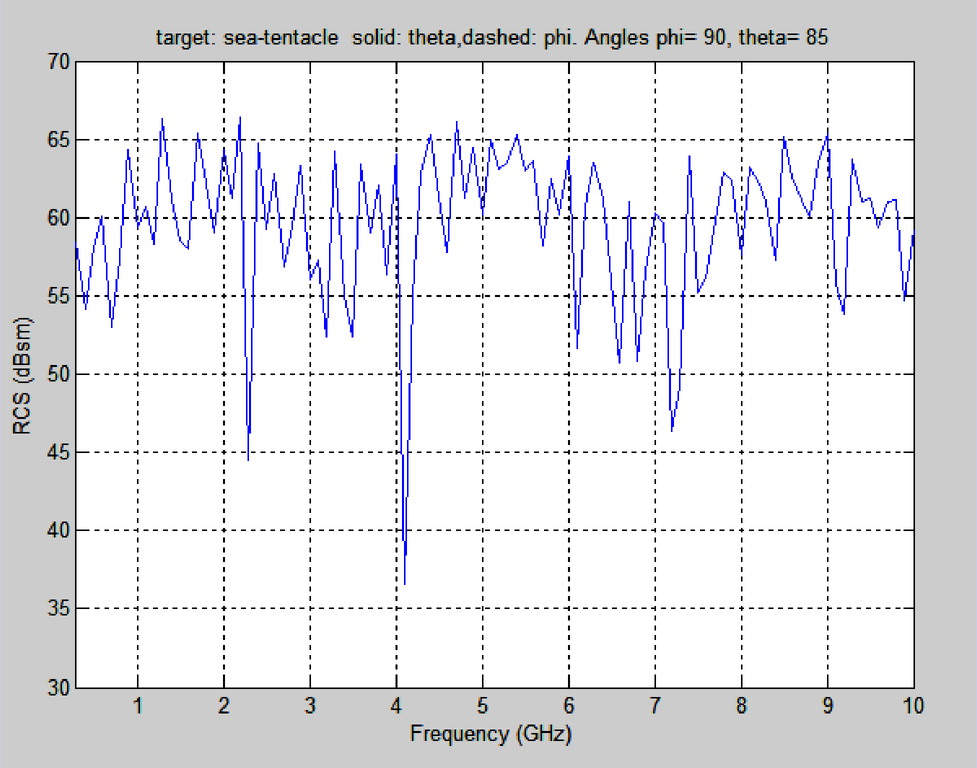
Composite vs. PEC (Steel)



Composite material ship yields a median RCS of approximately 5dBsm

Steel ship yields a median RCS of approximately 25dBsm

RCS as a Function of Seeker Frequency



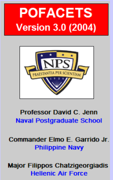
RCS Results using a Steel Ship model vs. Seeker frequency at a 090/270 TA

RCS: Beam target angle for steel ship.

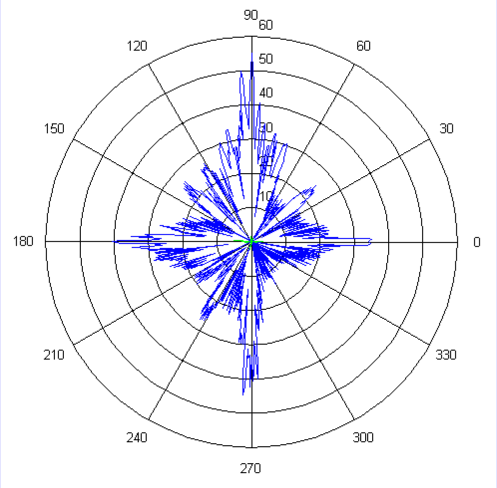
Steel material selection renders lowest RCS at frequencies:

- 2.3 GHz
- 4.1 GHz
- 7.2 GHz

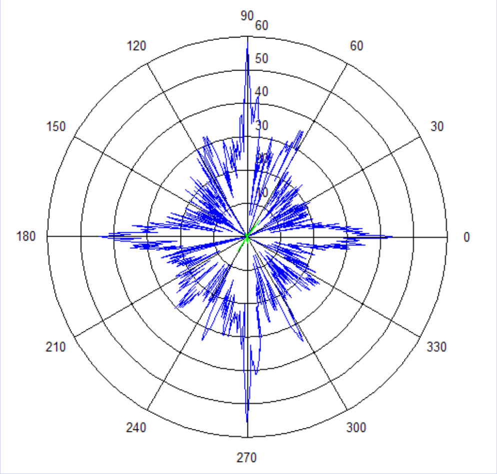
RCS Conclusions



- Empirical and simulation results for RCS are similiar.
- POFACETS results facilitated material considerations.
- RCS Comparisons are comparable between 2004 and 2005 TSSE designs.
- RCS Analysis (unclassified) and does not take into account AMRFS RF emissions.



ACCESS - 2004



TENTACLE - 2005

Combat Systems Top-Level Requirements

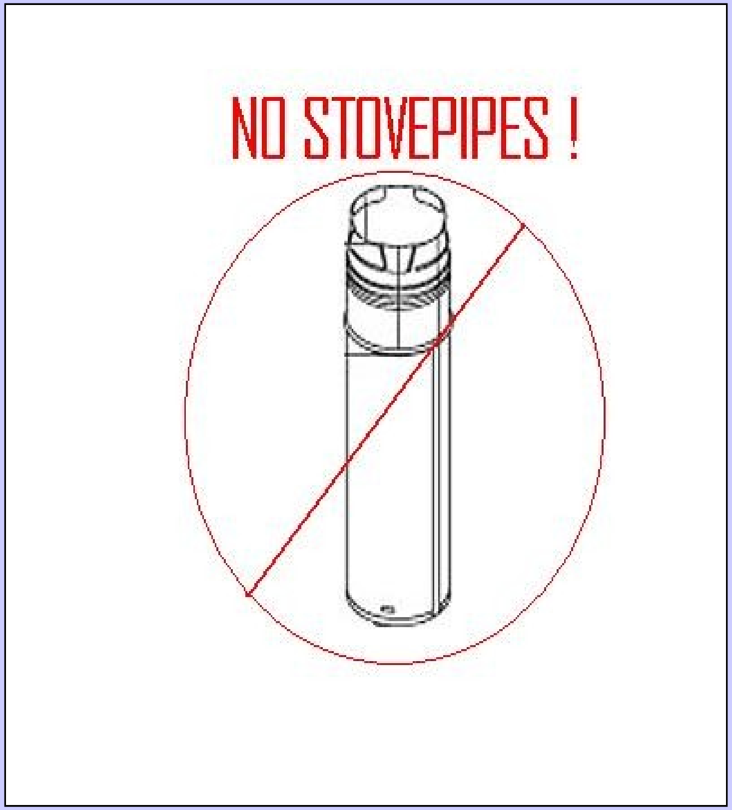
Deploy

Prepare system components | **Deliver system components** | **Sustain system components**

- Deploy, retrieve, and regenerate large UUVs semi-clandestinely
- Sensor assets required to provide Pd 0.8 across contested OA (6,700 NM2) within 10 days
- Provide logistic support necessary to sustain SoS for 30 days
- **Communicate on the following circuits:**
  - **High Band Width Air/Space Line of Sight (LOS)** - **LOS Data**
  - **LOS Voice** - **OTH Data**
  - **OTH Voice** - **SATCOM**
  - **Underwater Data**
- **Launch, recover, and control a 7,000 lb UAV**
- **Deploy box-launcher weapons and torpedoes for enemy engagement**

ICMS Summary

- Integrated Design philosophy can summed up as “no stovepipes.”
- Open Architecture Focus Embraces Technology Growth.
- Multi-mission capability supports dynamic mission requirements.

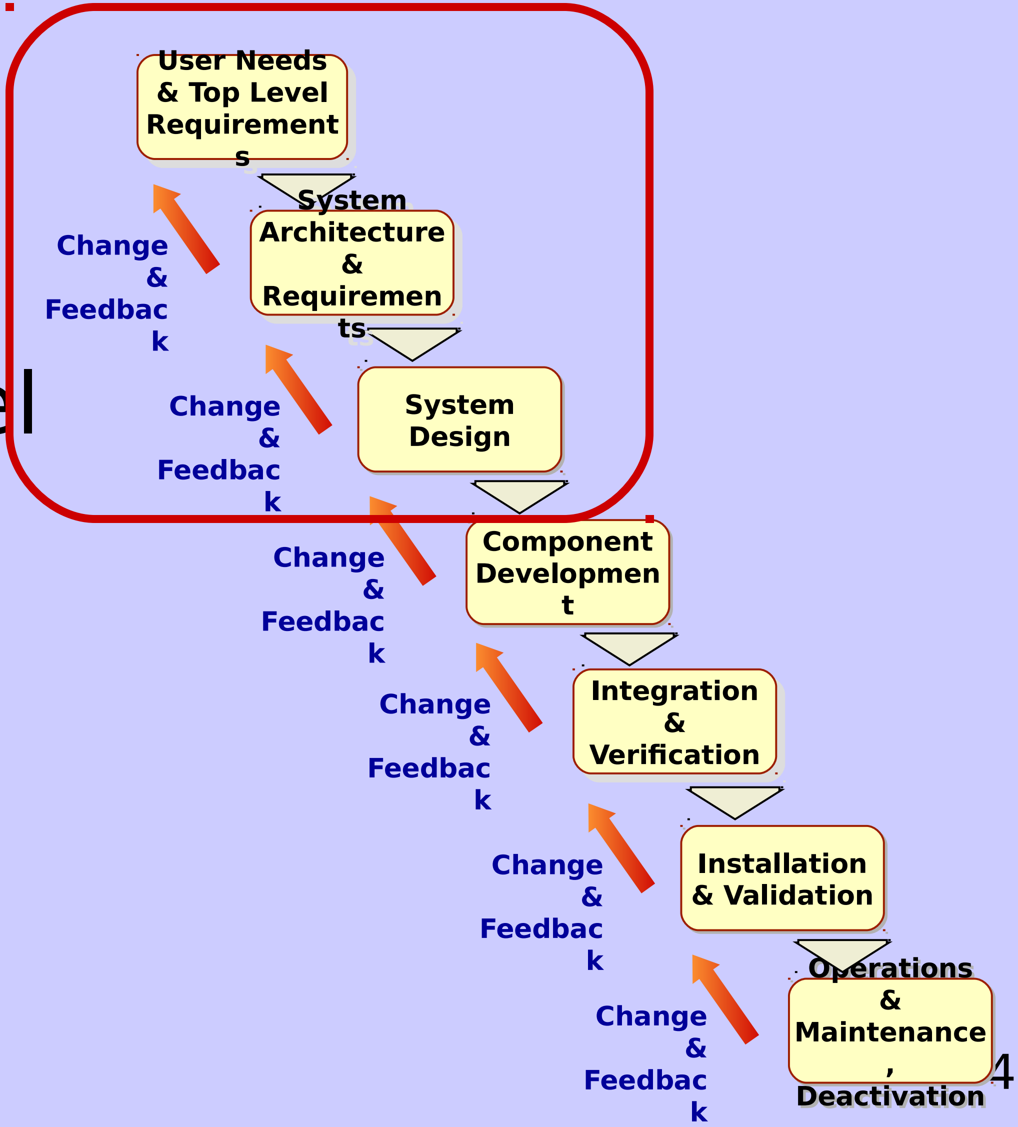


Agenda

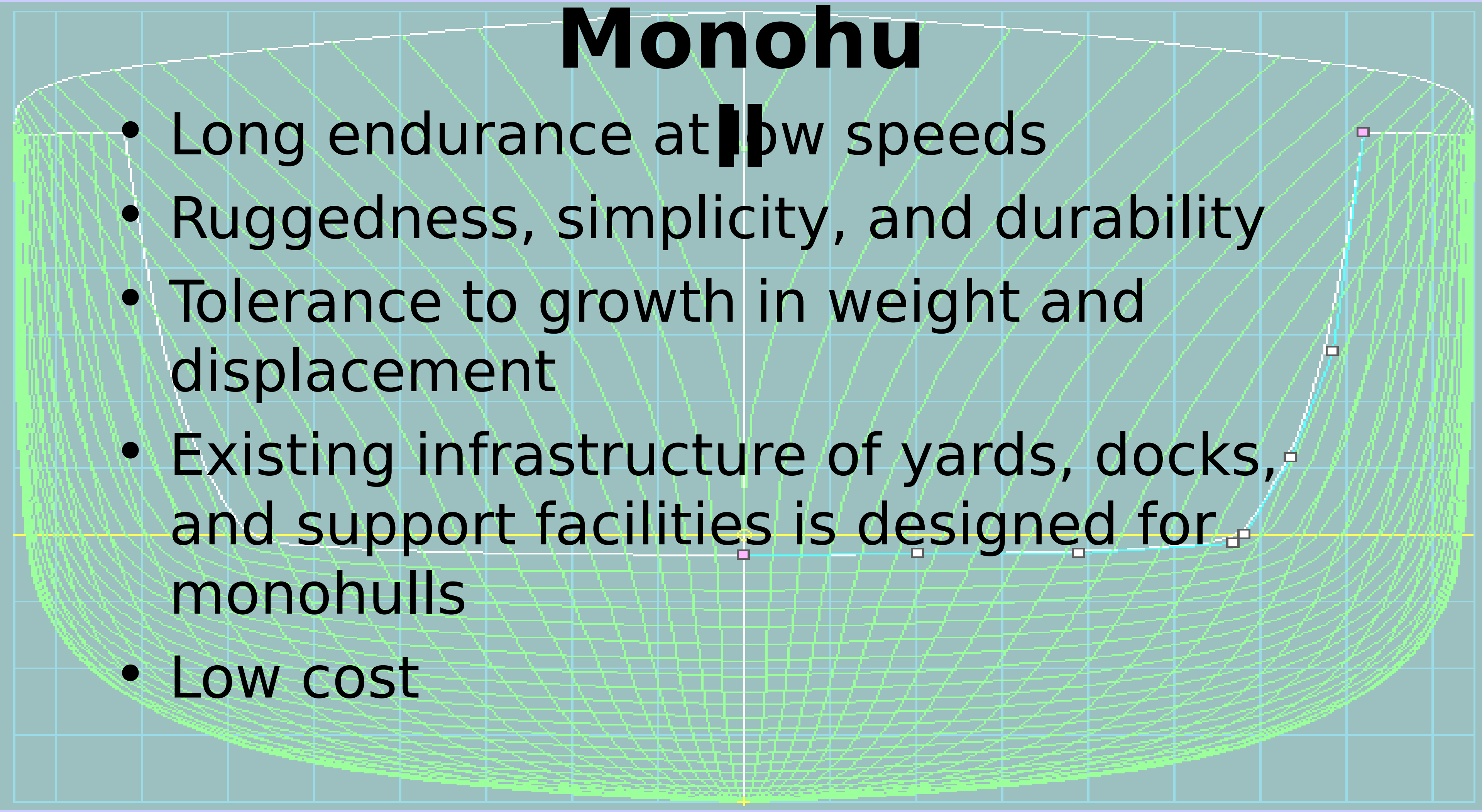
- ✓ Introduction and Overall Design Process
- ✓ Payload and Operational Concept
- ✓ Combat Systems
- Hull, Mechanical, and Electrical (HM&E)
  - Initial Hull Selection AoA
  - Hydrostatics, Damaged Stability, Structures
  - Resistance, Propulsion, Electrical
  - Seakeeping
- Summary

Hull Selection

- Systems Engineering Waterfall Model used
- Applied up to component development stage



Monohull



- Long endurance at low speeds
- Ruggedness, simplicity, and durability
- Tolerance to growth in weight and displacement
- Existing infrastructure of yards, docks, and support facilities is designed for monohulls
- Low cost

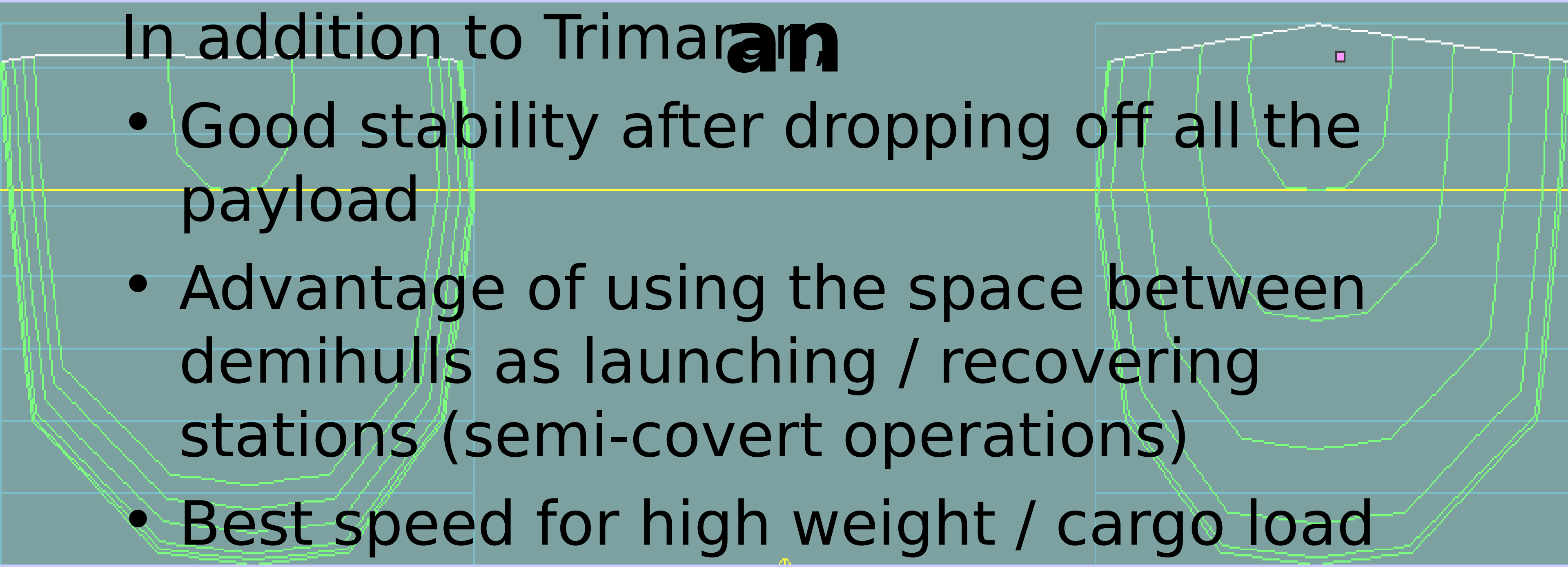
Hull Type Comparison

Trimaran

- Reduced powering requirements at high speeds
- Reduced draft
- Increased deck area and growth margin
- Increased seakeeping
- Increased powering requirements at low speeds because of large wetted surface area

Hull Type Comparison

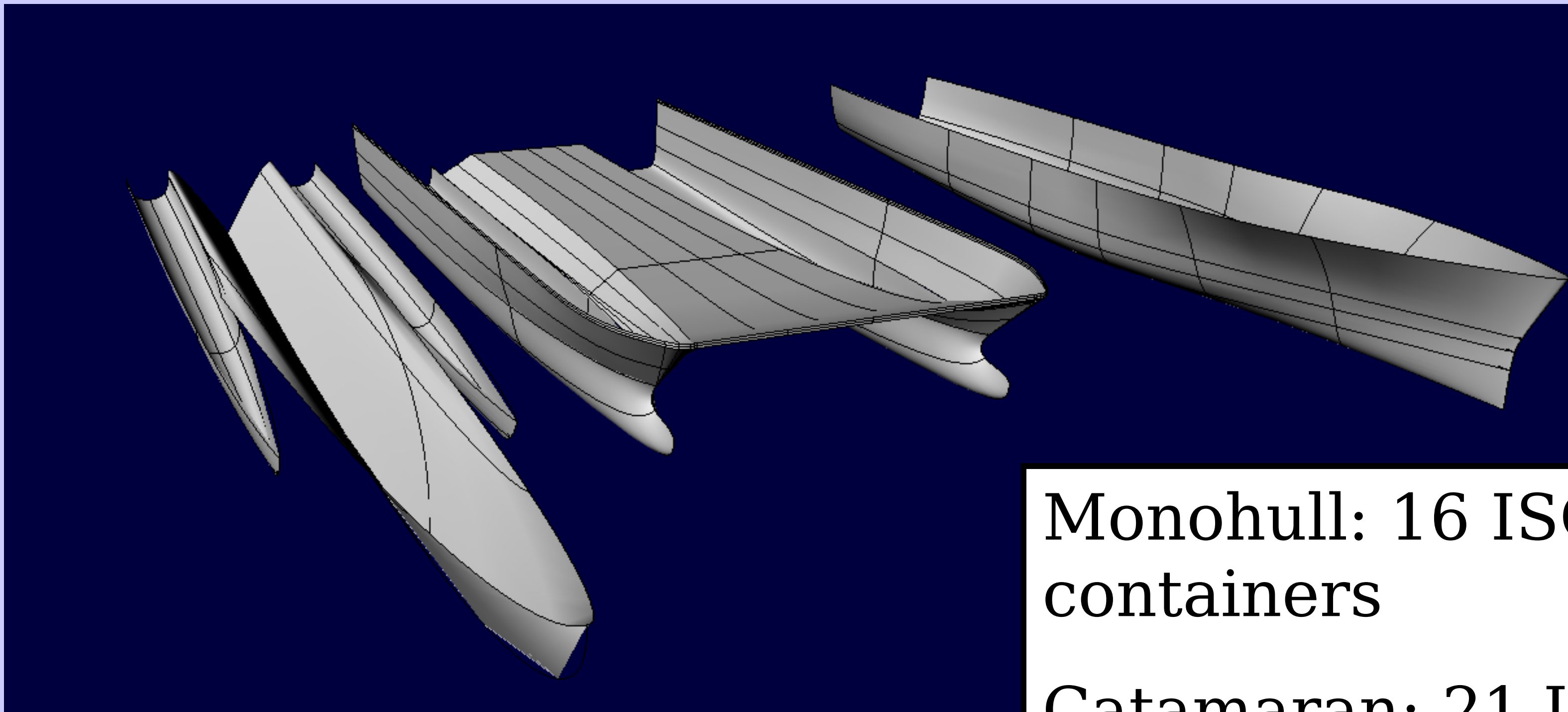
Catamaran



In addition to Trimaran,

- Good stability after dropping off all the payload
- Advantage of using the space between demihulls as launching / recovering stations (semi-covert operations)
- Best speed for high weight / cargo load

Mission Bay Comparison



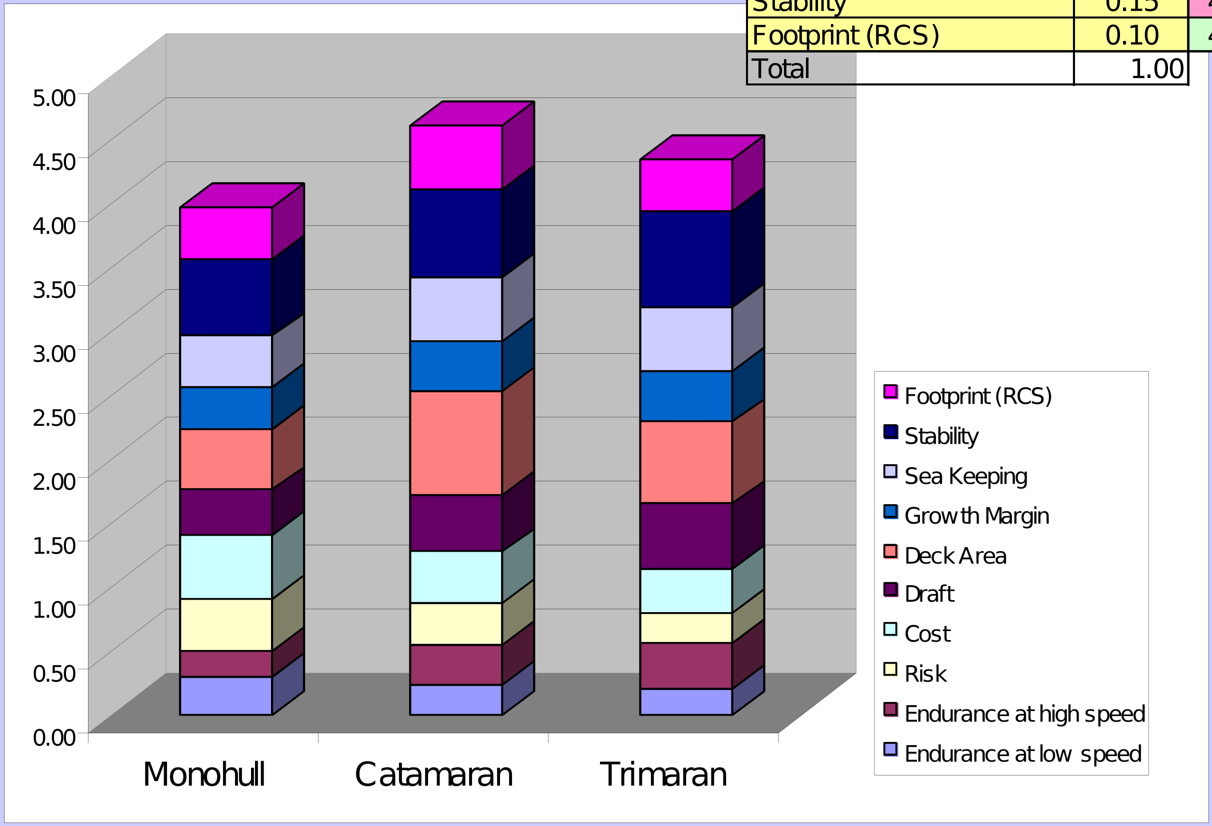
Monohull: 16 ISO containers

Catamaran: 21 ISO containers

Trimaran: 7 ISO containers

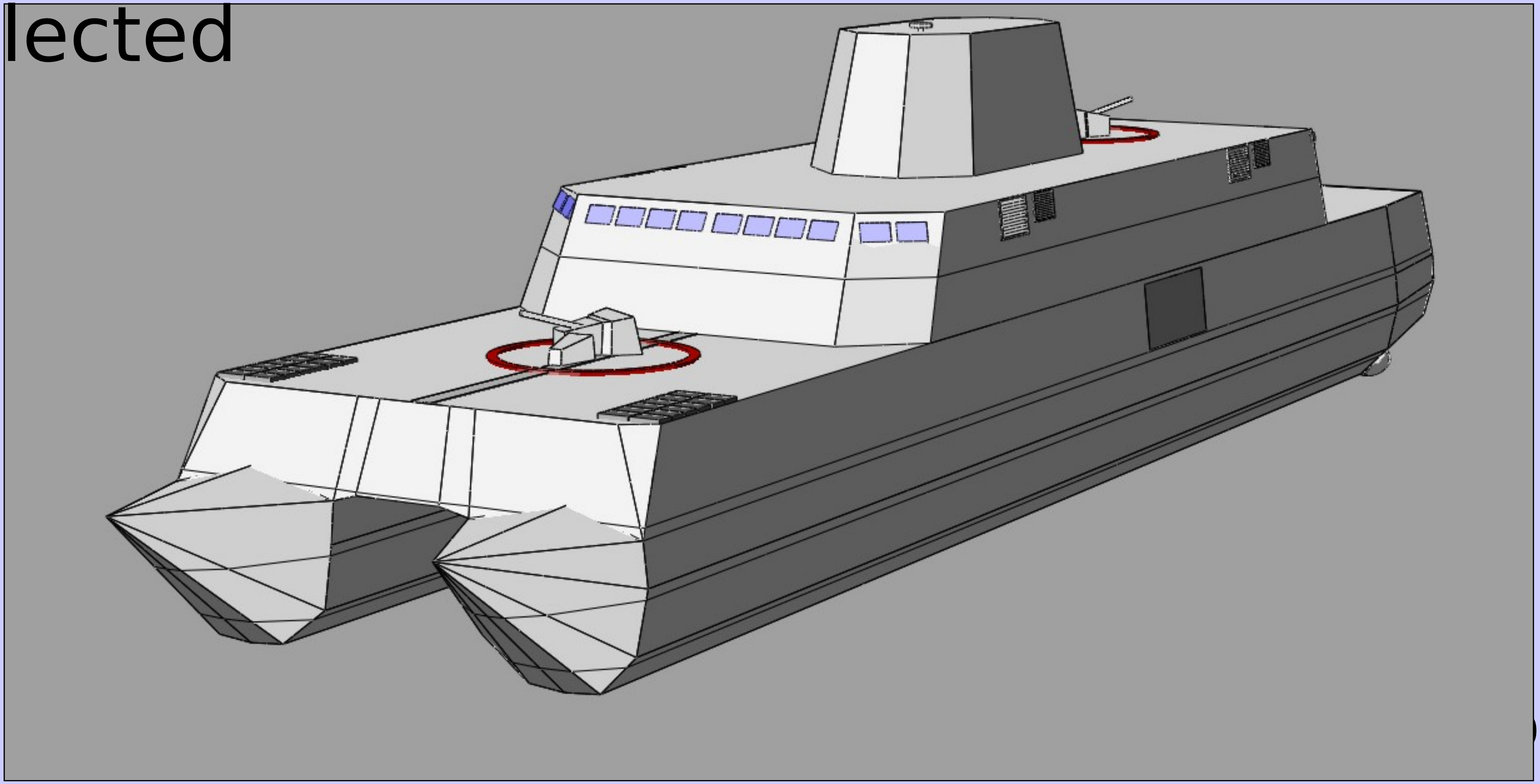
Hull Type AoA

Requirement	Weight	Monohull		Catamaran		Trimaran	
			Weighted		Weighted		Weighted
Endurance at low speed	0.06	5.00	0.30	4.00	0.24	3.50	0.21
Endurance at high speed	0.07	3.00	0.21	4.50	0.32	5.00	0.35
Risk	0.08	5.00	0.40	4.00	0.32	3.00	0.24
Cost	0.10	5.00	0.50	4.00	0.40	3.50	0.35
Draft	0.10	3.50	0.35	4.50	0.45	5.00	0.50
Deck Area	0.16	3.00	0.48	5.00	0.80	4.00	0.64
Growth Margin	0.08	4.00	0.32	5.00	0.40	5.00	0.40
Sea Keeping	0.10	4.00	0.40	5.00	0.50	5.00	0.50
Stability	0.15	4.00	0.60	4.50	0.68	5.00	0.75
Footprint (RCS)	0.10	4.00	0.40	5.00	0.50	4.00	0.40
Total	1.00		**0.79**		**0.92**		**0.87**

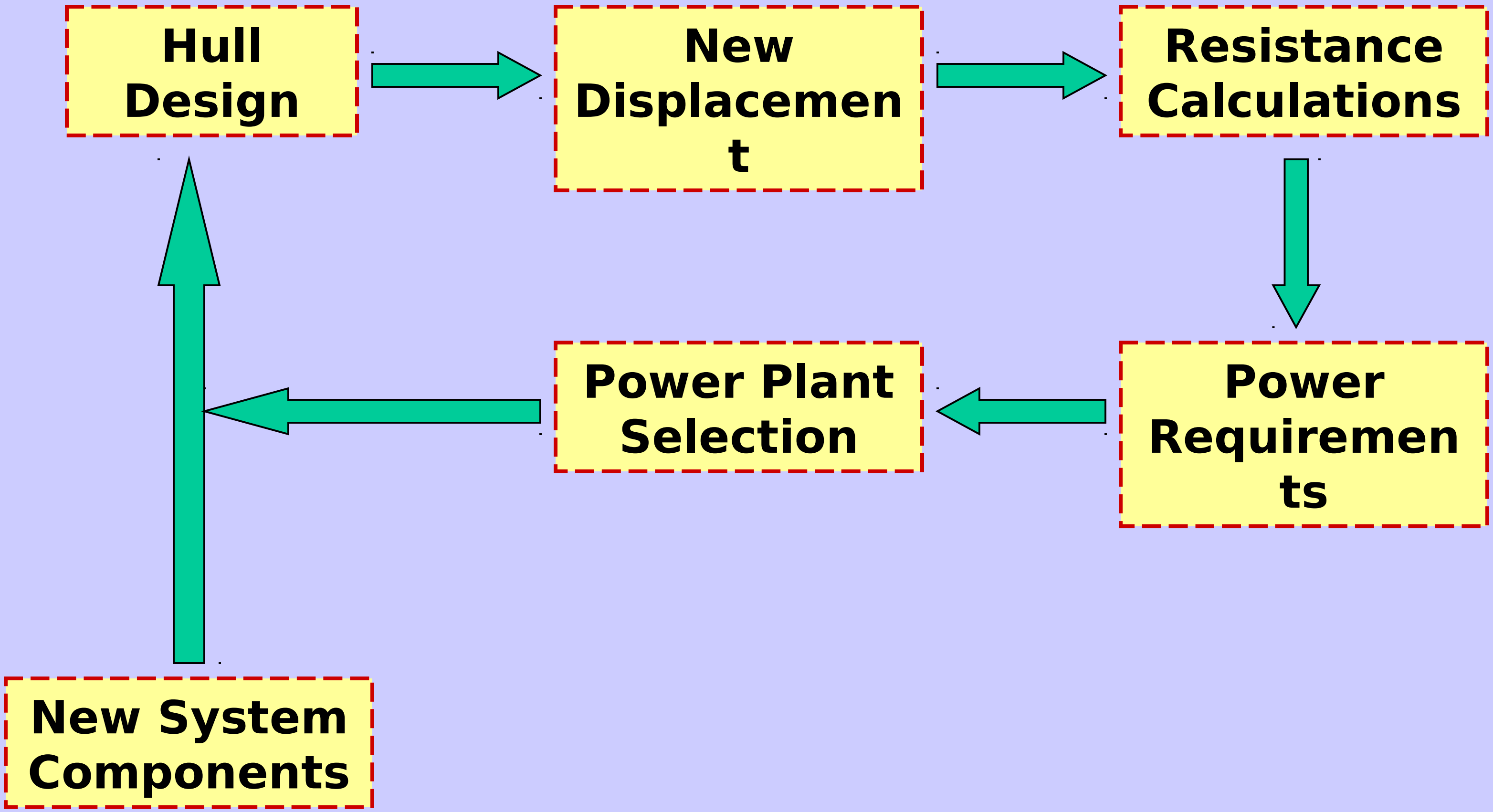


Hull Form

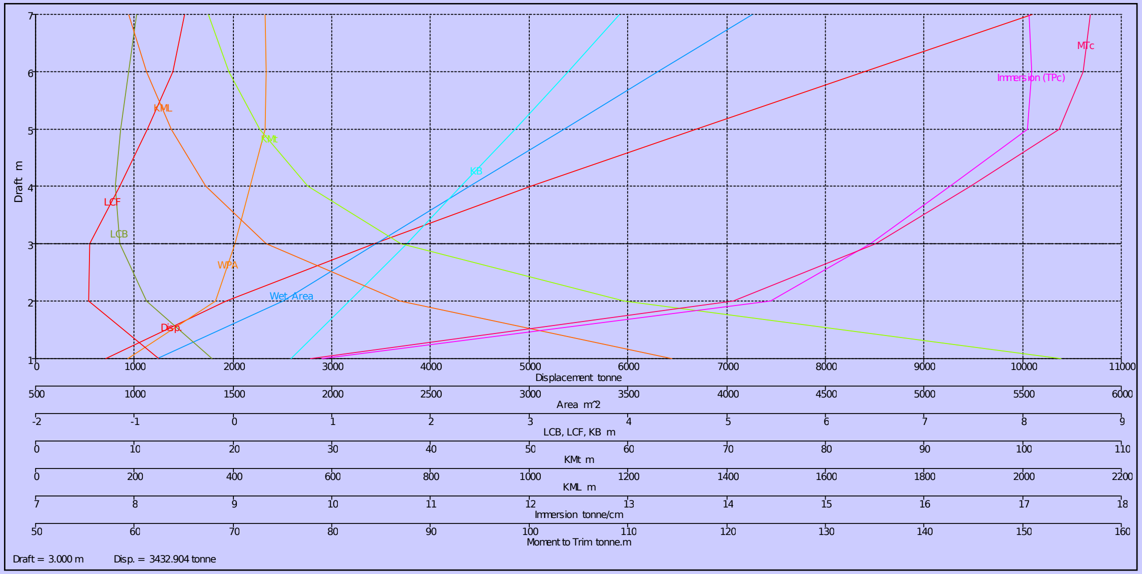
Catamaran was selected



Hull Design


Hull Design
New Displacement
Resistance Calculations
Power Requirements
Power Plant Selection
New System Components

Hydrostatics

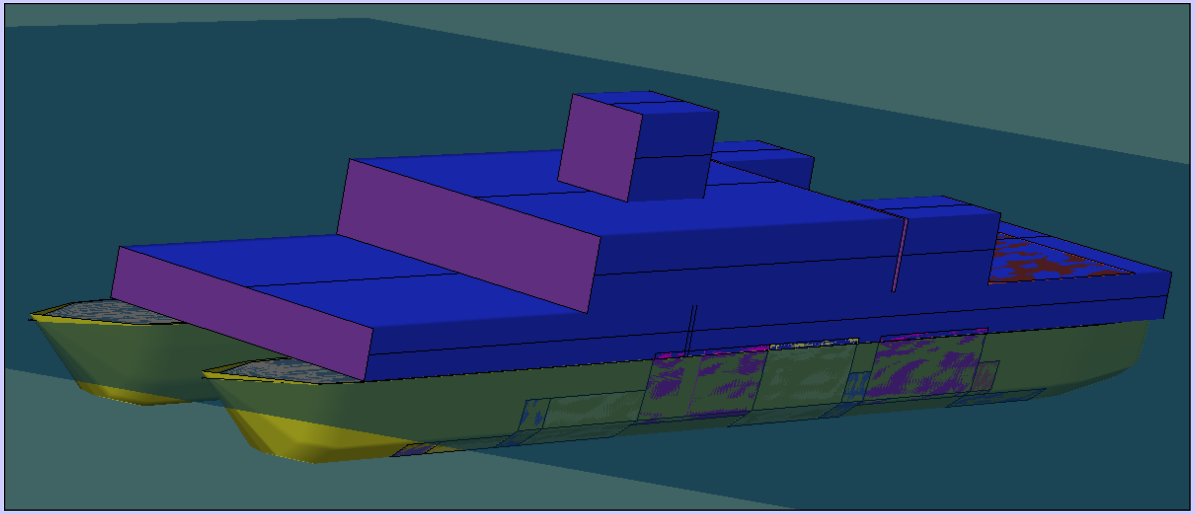


Displacement = 7023 MT

DWL = 117.4 m

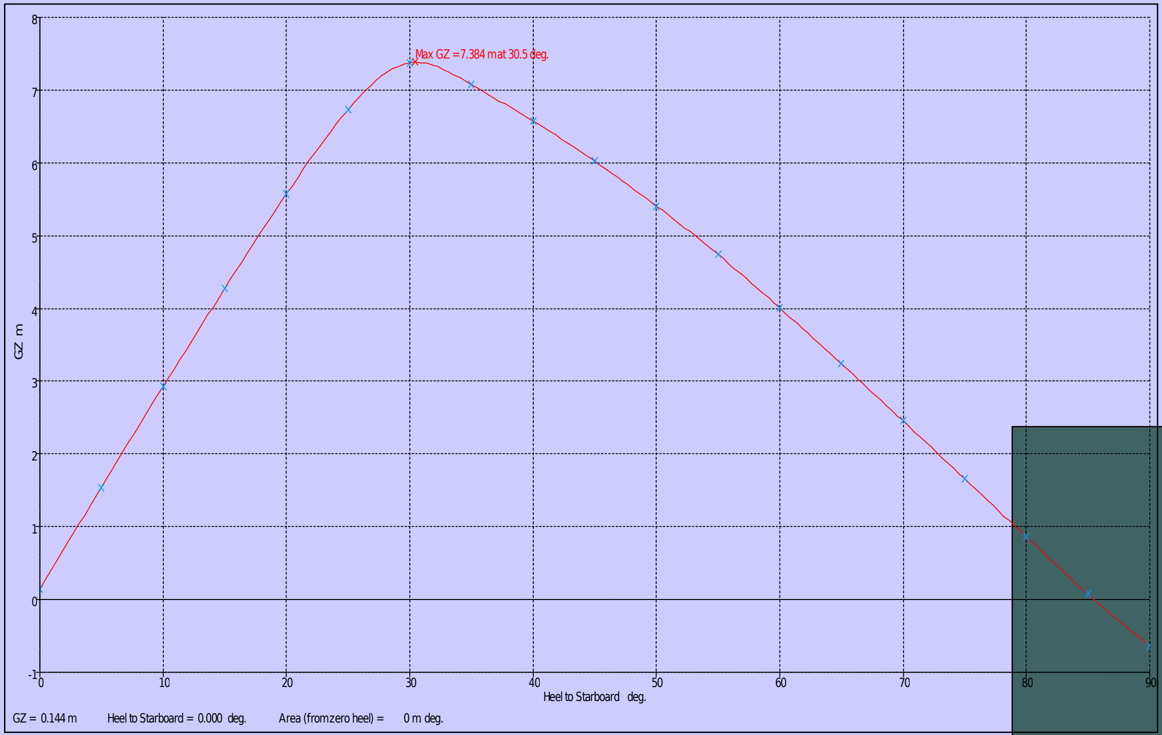
Design Draft = 5.2 m

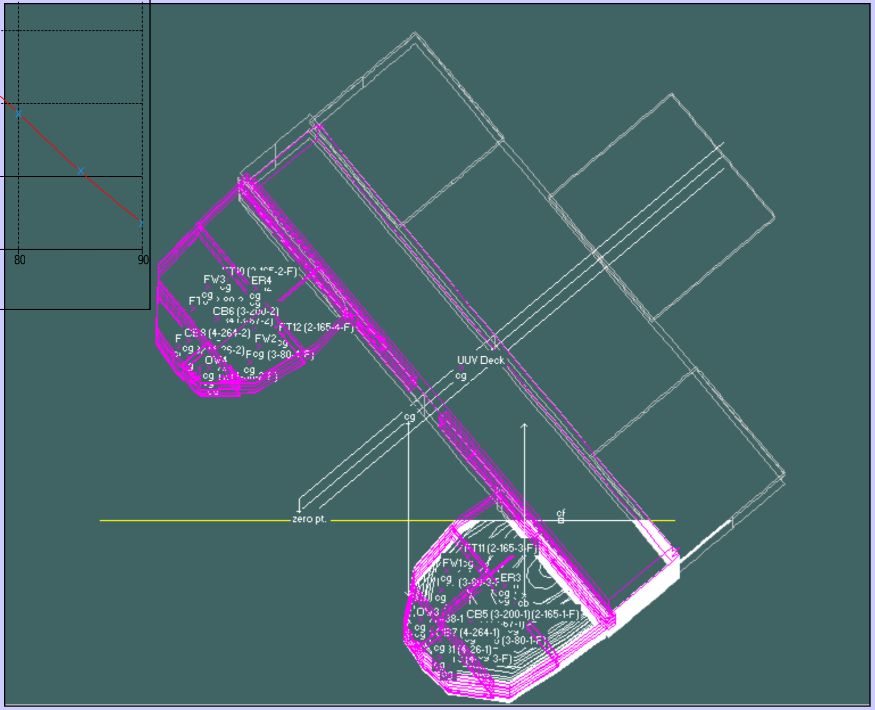
VCG = 5.925 m (from keel)



Results obtained using standard and custom hydrostatics software and weight data for the ship

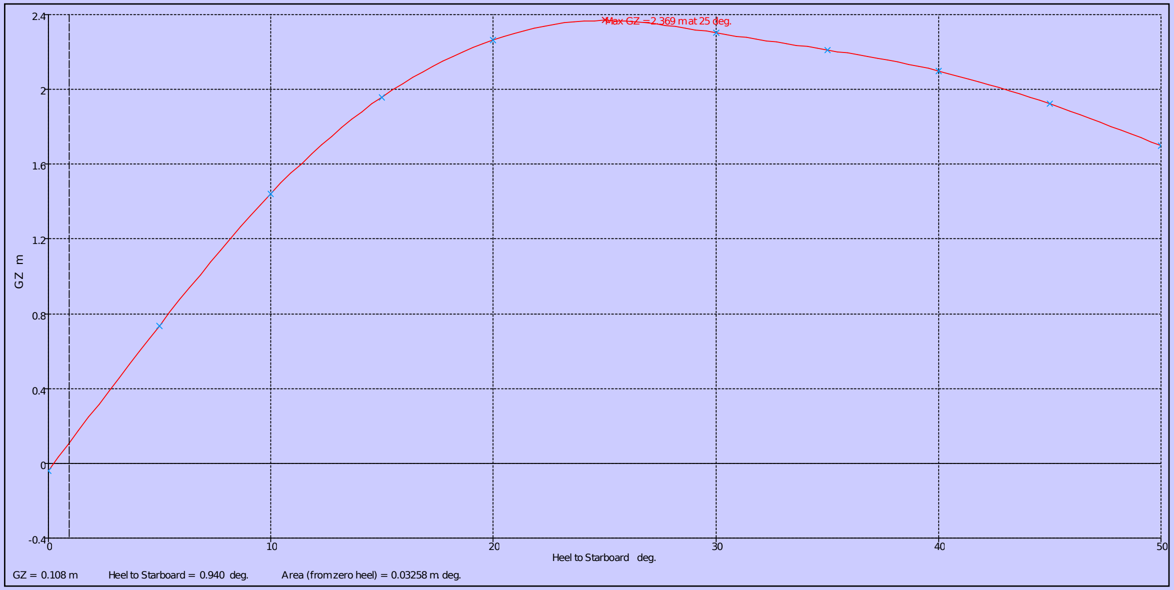
Intact Stability





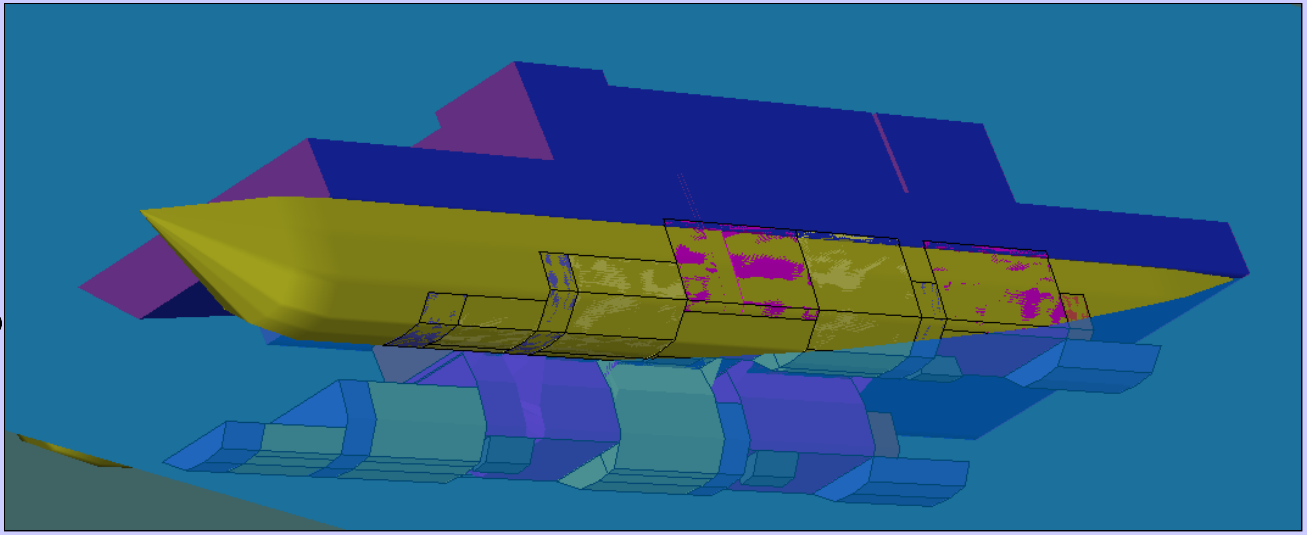
Positive Righting Arm up to 85^{o}

Damaged Stability

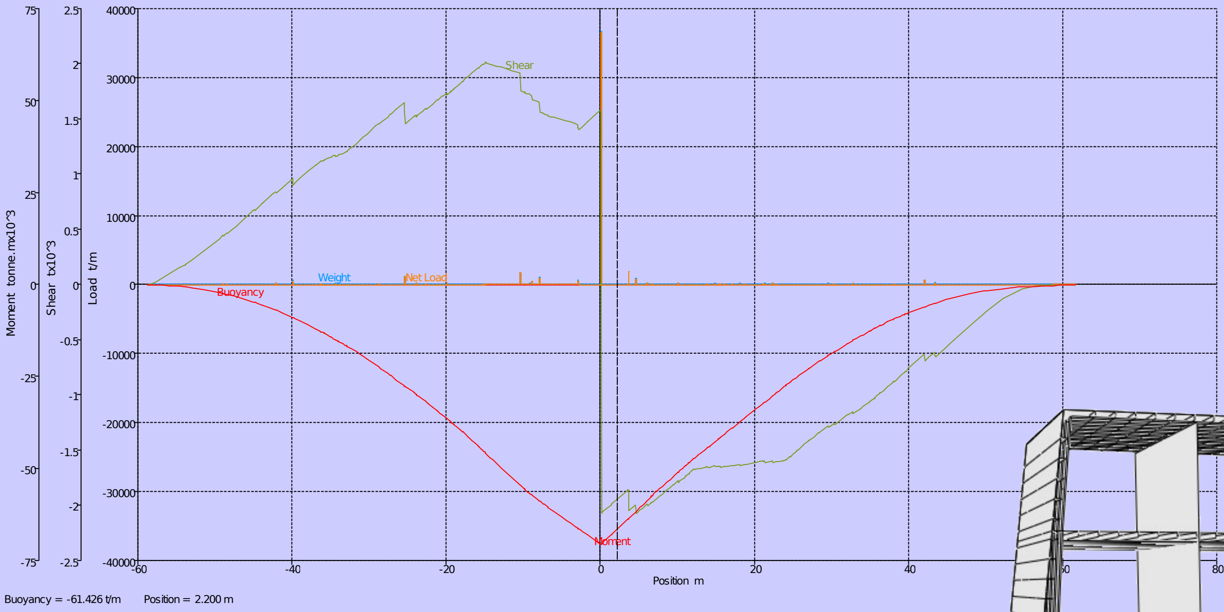


Can survive in case of loss of one demi-hull

Can survive with all engine rooms flooded

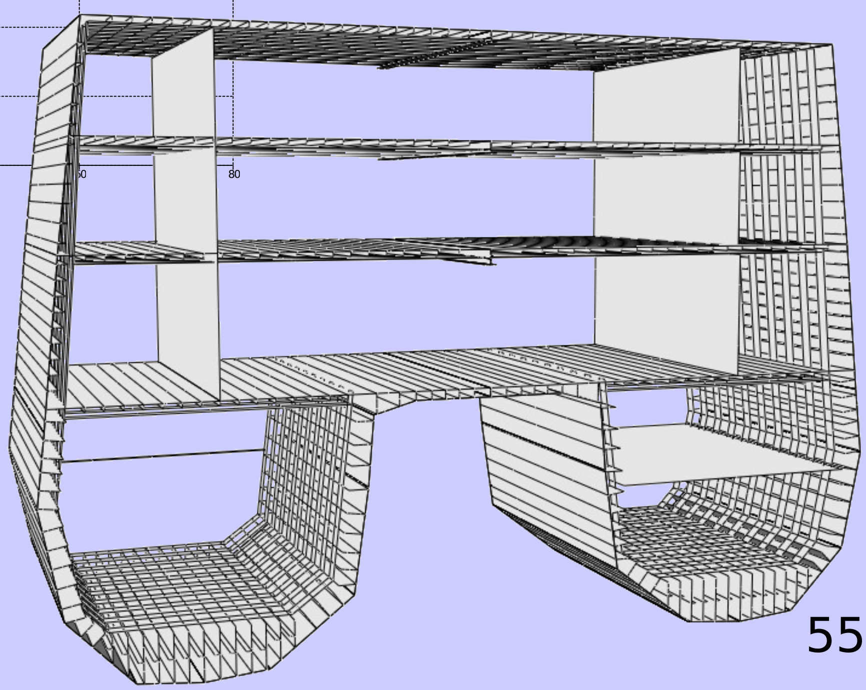


Structural Strength



Steel was selected

Max. Bending Stress = 154.4 MPa at hogging condition at midship section



Ship Characteristics

Light Ship = 4504 MT

Loaded Displacement = 7023 MT

LOA = 120 m

LWL = 117.4 m

Beam = 25 m

Design Draft = 5.2 m

Metacentric Height = 16.05 m

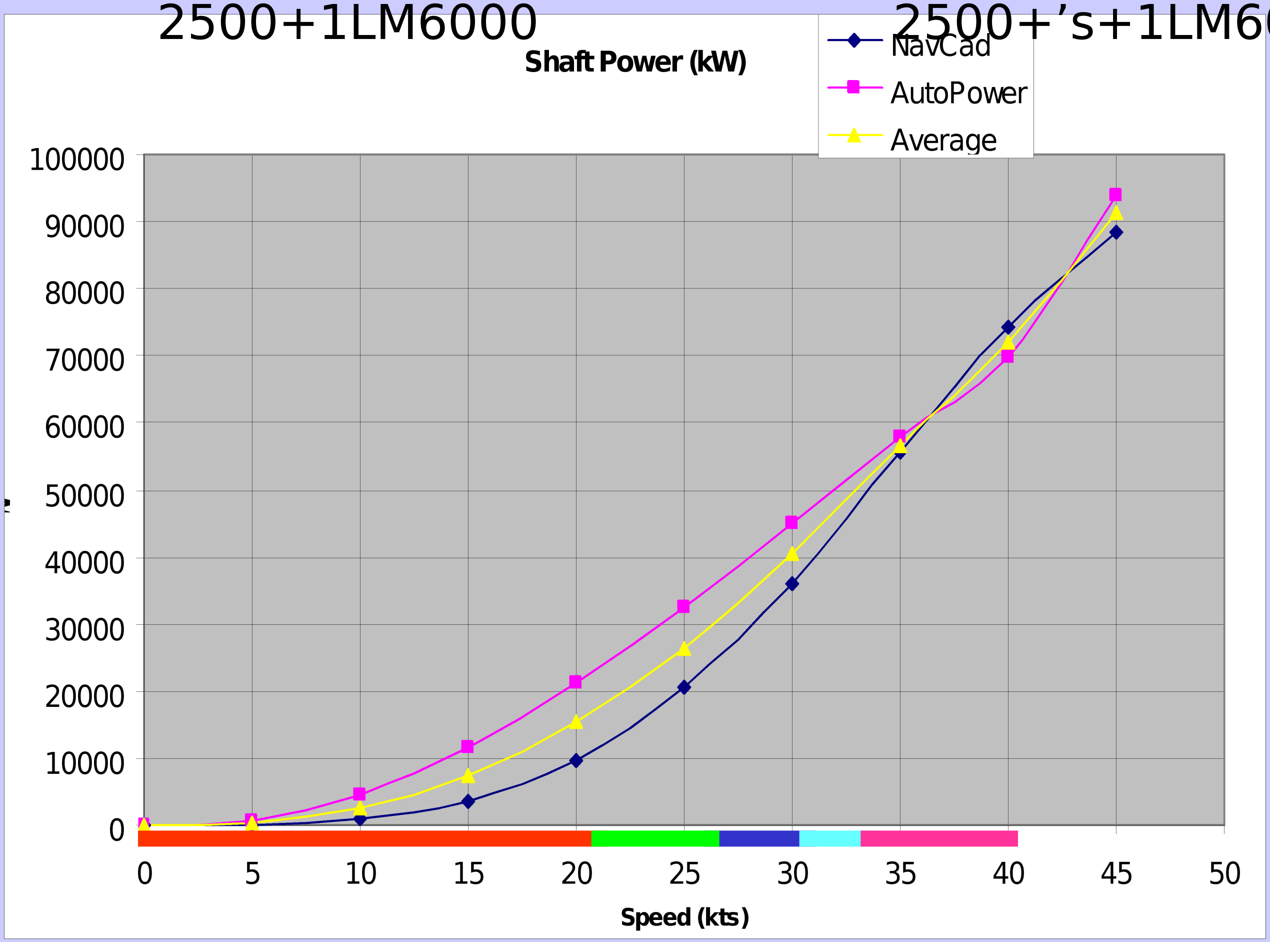
Design Trim = 0.1° to Bow

Design Heel = 0.51° to Port

Power Estimation from Resistance Calculations

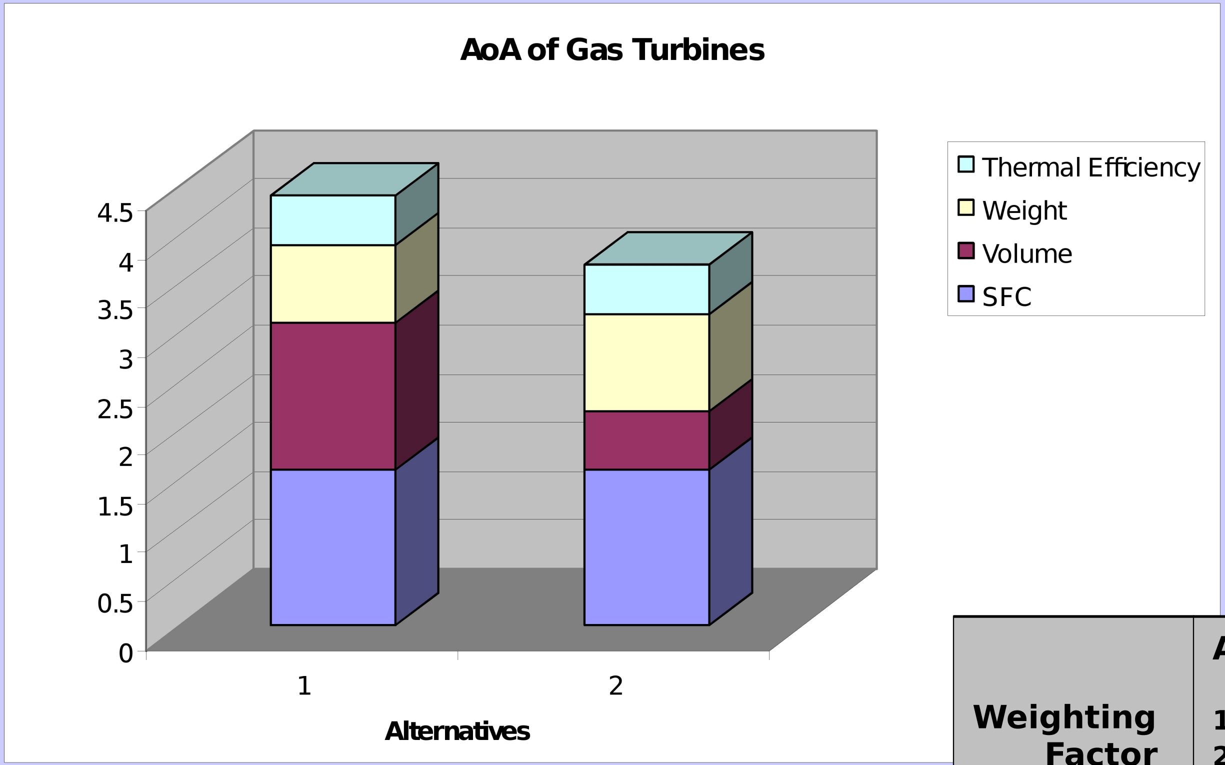
1LM 2500+ 1LM 6000 2LM 2500+'s

1LM 2500+1LM6000 2LM 2500+'s+1LM6000



Speed	Shaft Power (kW)
0	0
5	403.02
10	2645.84
15	7528.65
20	15419.89
25	26510.43
30	40627.94
35	56712.14
40	72155.12
45	91213.34

Gas Turbine Analysis Snapshot



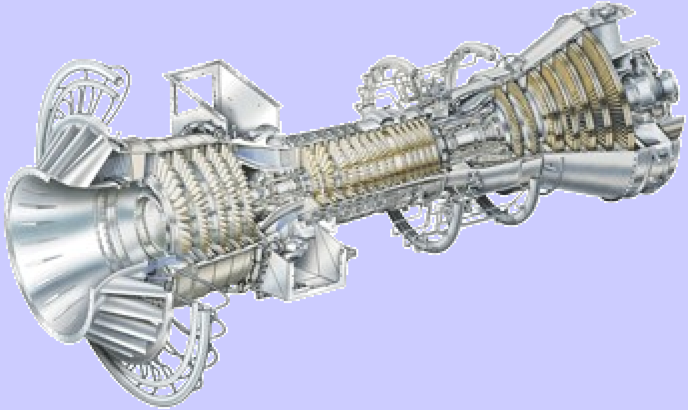
	Weighting Factor	Alternative – 1 1-LM6000 2 LM2500+	Alternative – 2 2 MT30 1 LM2500+
Specific Fuel Consumption	0.4	4	4
Volume	0.3	5	2
Weight	0.2	4	5
Thermal Efficiency			

Summary of Chosen Propulsion Systems

- Propulsion Plant: Gas Turbines
- Specifically: 2 LM2500+

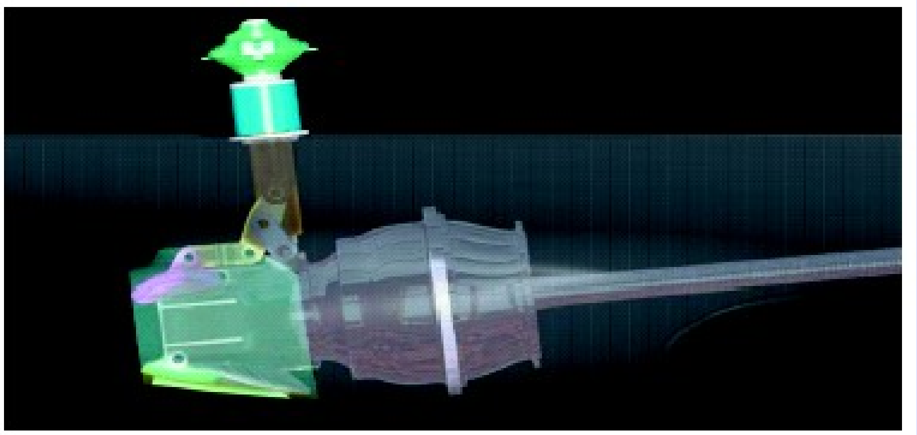
  1 LM6000

  1 Allison 501-K34

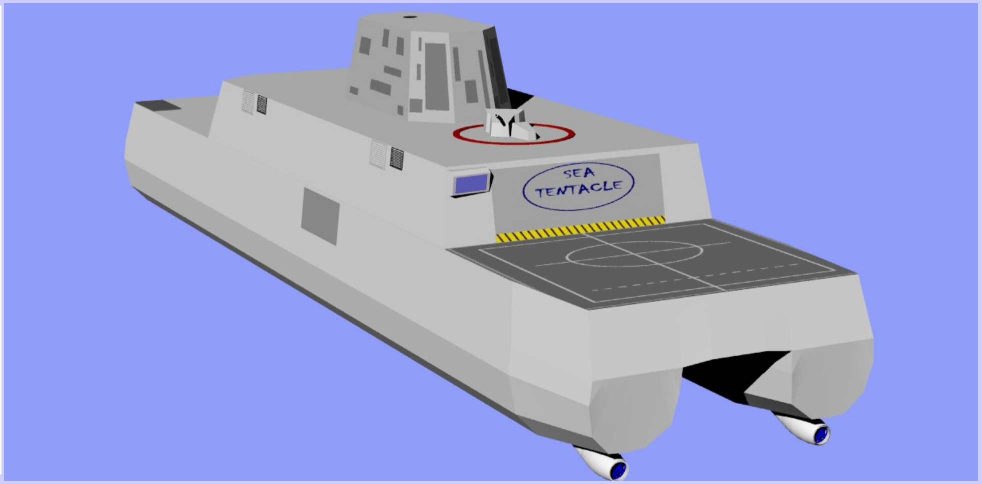


Summary of Chosen Propulsion Systems

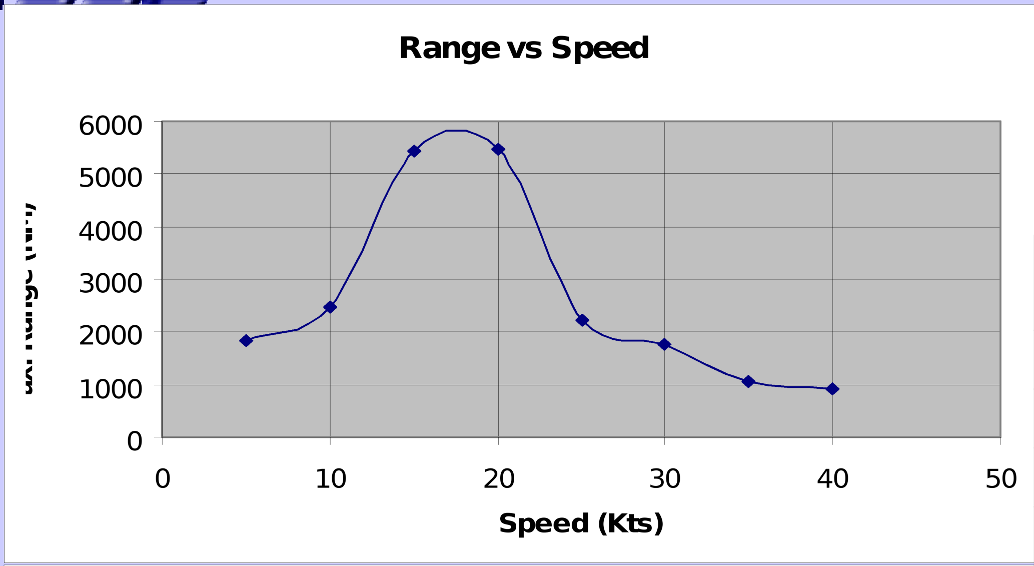
- Electric drive
- 2 Bird-Johnson AWJ-21 water jets
- 2 bow thrusters

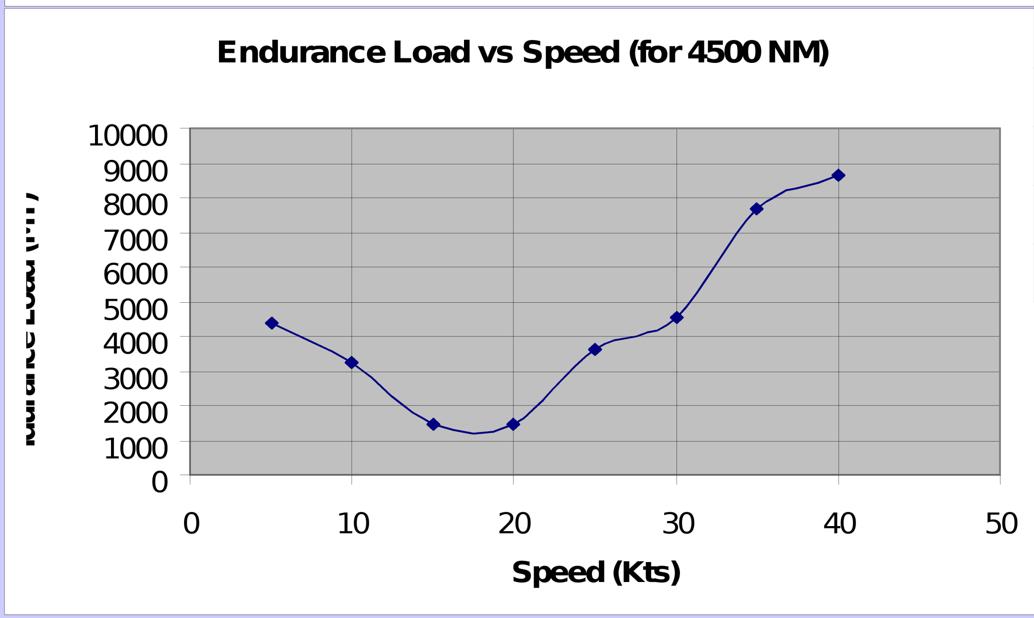


View showing AWJ-21™ and underwater nacell



Range Calculations





Speed (kts)	Max. Range (NM)	Speed (kts)	Endurance Load for 4500 NM (MT)
5	1831.094	5	4367
10	2468.7828	10	3239
15	5439.71939	15	1470
20	5462.01332	20	1464
25	2212.61414	25	3614
30	1754.36321	30	4558
35	1045.41607	35	7649
40	921.880044	40	8674

Endurance and Speed

- Transiting Speed of 20 kts gives Range of 5,400 nm

Max Speed 40 kts

- Sprint Speed of 35 kts gives Range of 1,000 nm

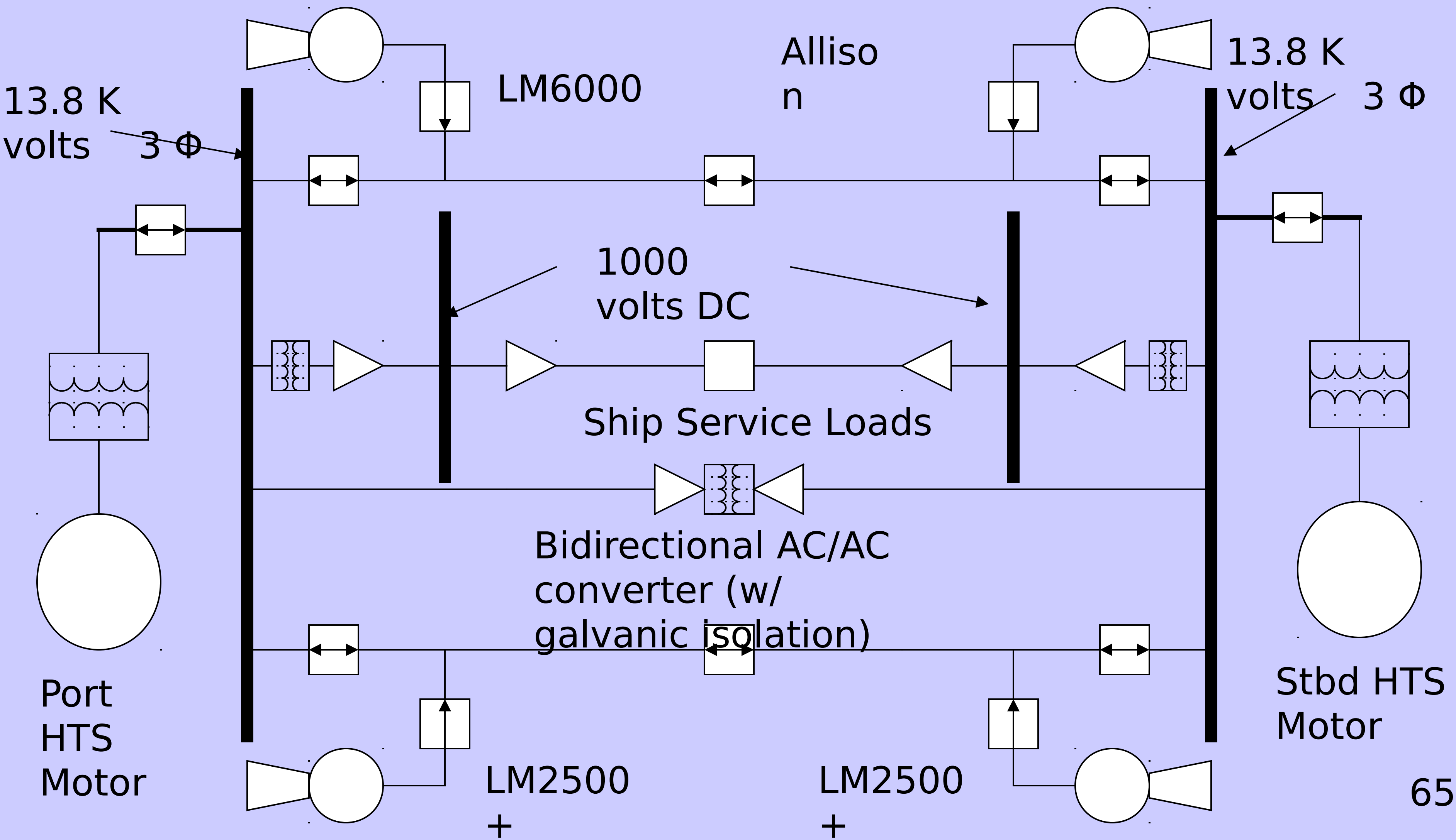
Summary of Chosen Motor System

- Motor alternatives:
  - Conventional COTS motor
  - Superconducting DC Homopolar motor
  - High Temperature Superconducting AC motor
- High Temperature Superconducting Synchronous AC Motor Selected

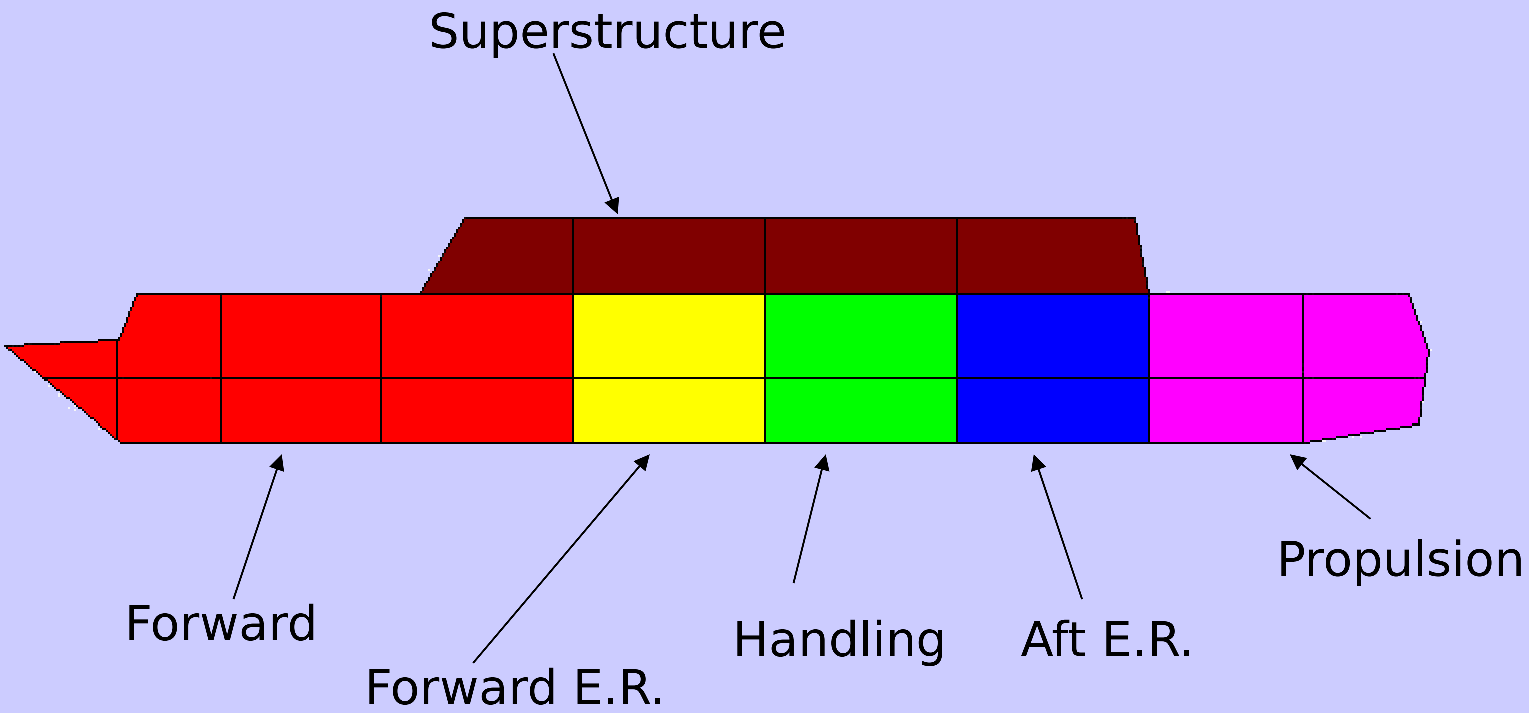
Integrated Power System

- IPS is an AC/DC hybrid zonal
- Total capacity is 103 MW
- 93 MW required for 40 knots, 6MW for ship service loads, 4 MW reserve
- Gas turbines produce 3 phase 13.8 kVolt AC
- All ship service loads distributed via 1000 volts DC

Sea Tentacle Electric Plant



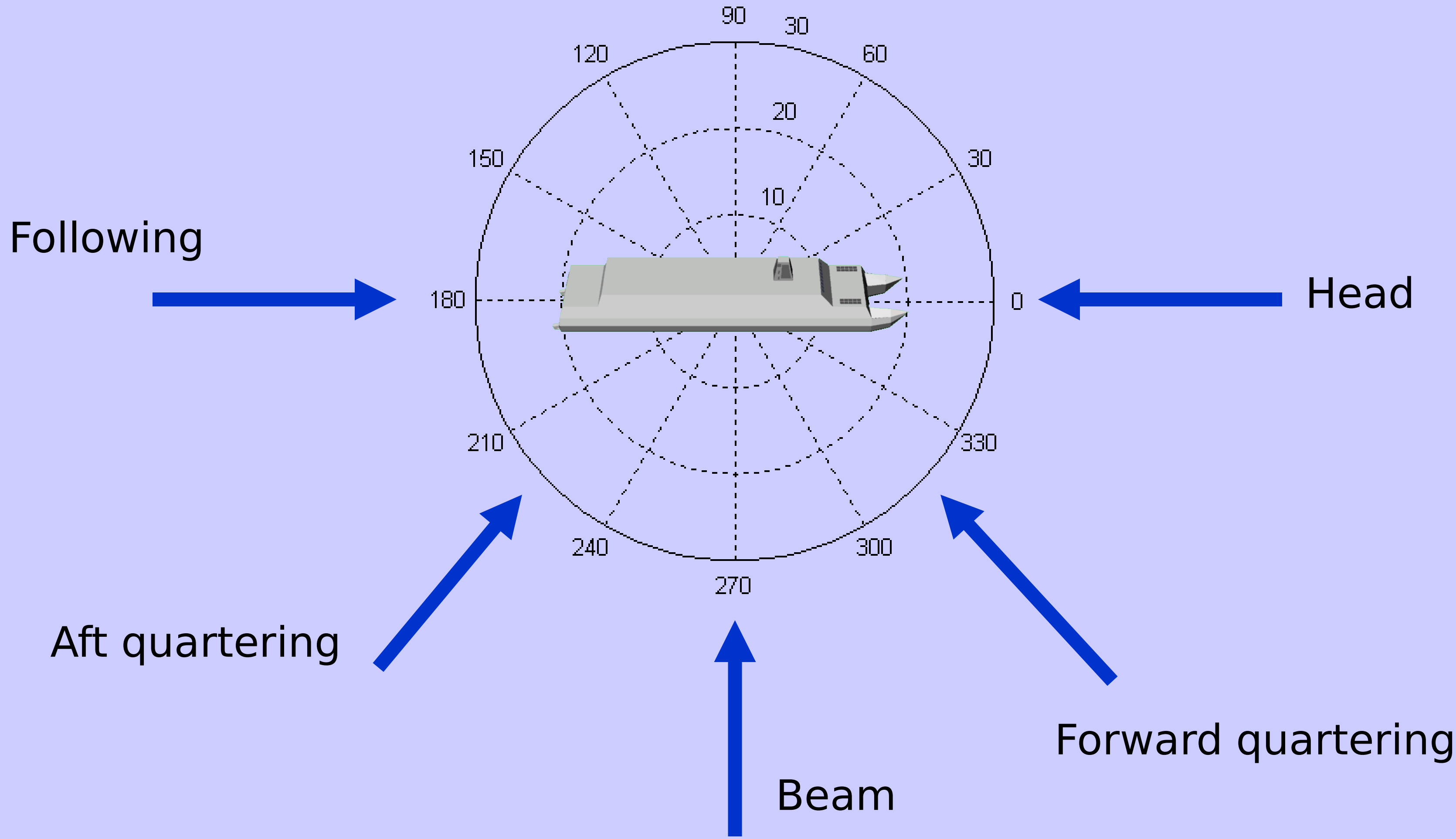
Zonal Distribution



Seakeeping Results

- Evaluate response in regular seas; varying ship speeds and headings.
- Within linear theory, evaluate response in random seas using regular wave results.
- Assume long-crested, fully developed seas.
- Set limiting values of the response and calculate the operating envelope.
- Adjust design parameters to achieve an acceptable operating envelope.

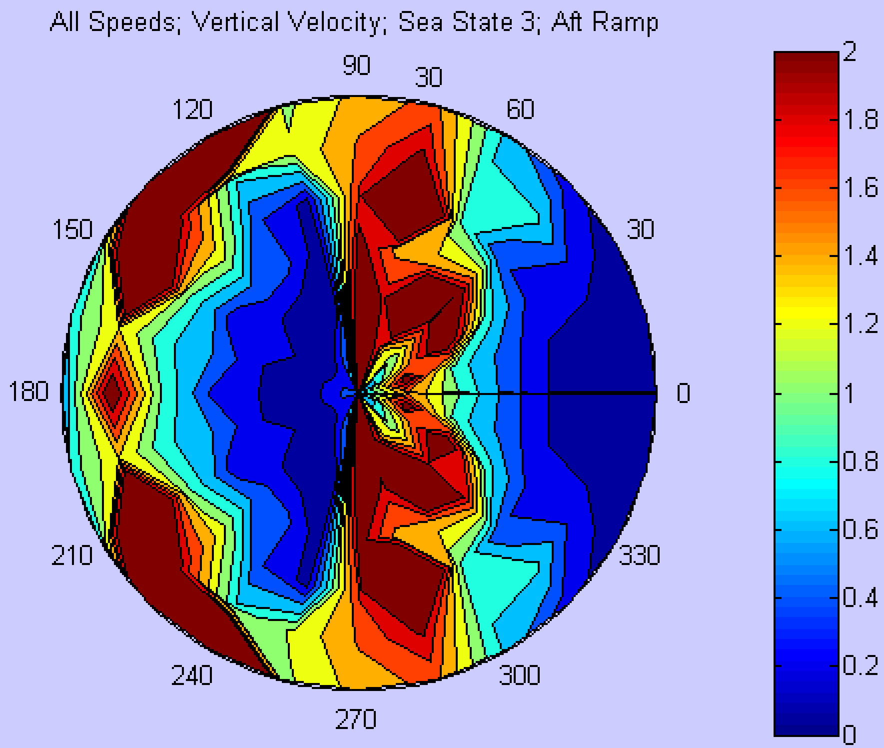
Speed-Polar Plot



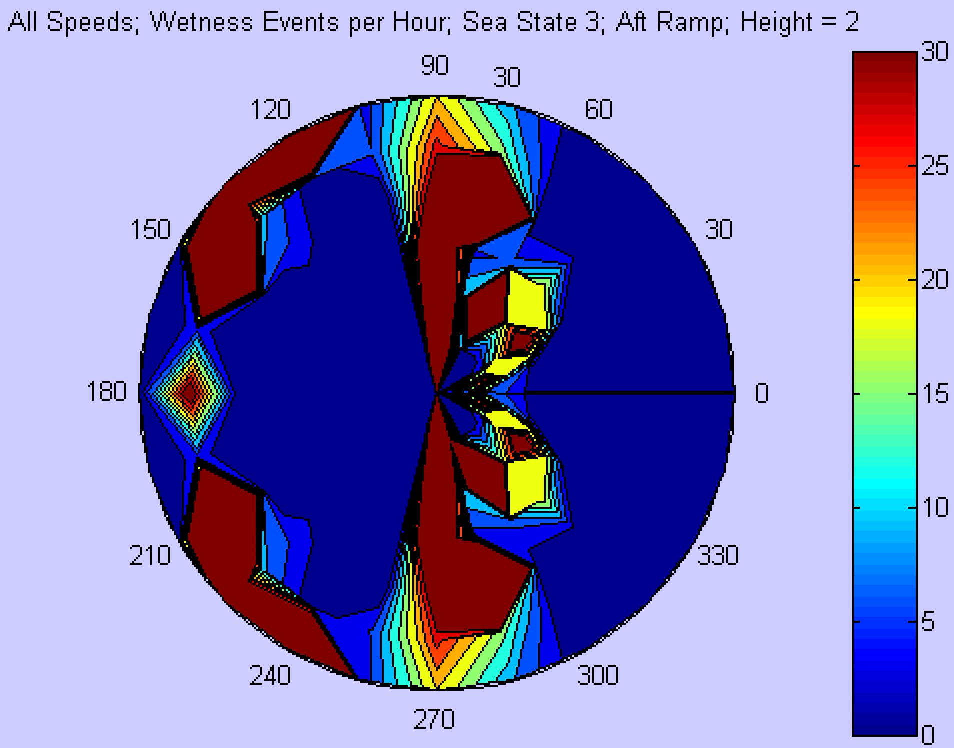
Limiting Values

- Assume the following limiting values for the responses:
  - Significant single amplitudes:
    - Ship roll: 5 deg.
    - Ship pitch: 3 deg.
    - Absolute vertical velocity at ramp: 2 m/sec
      - Depends on ramp (x,y) location
  - Expected number of events per hour:
    - Wetness (relative vertical motion hits zero) events at ramp: 30
      - Depends on ramp (x,y,z) location

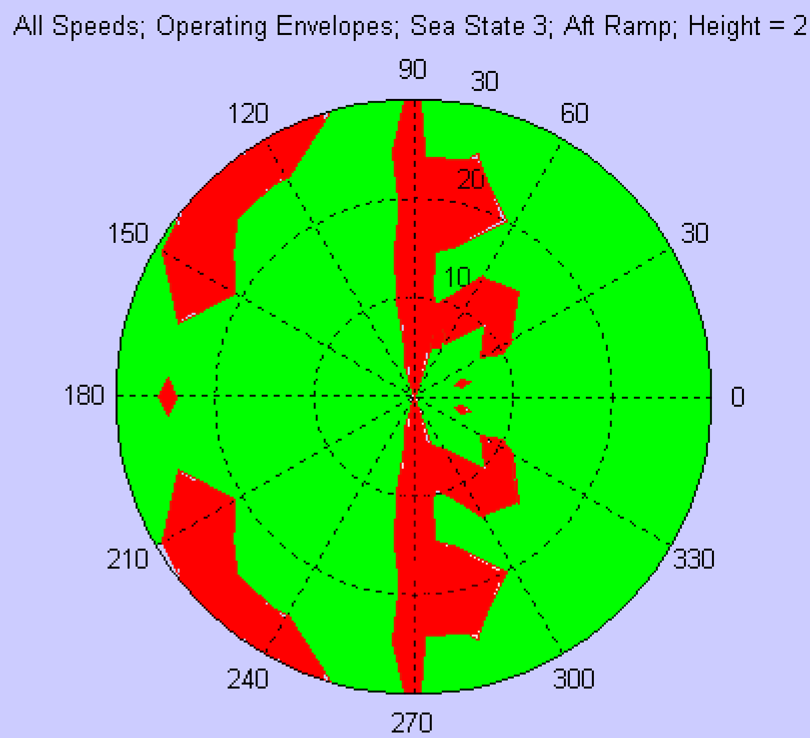
Vertical Velocity



Wetness Events



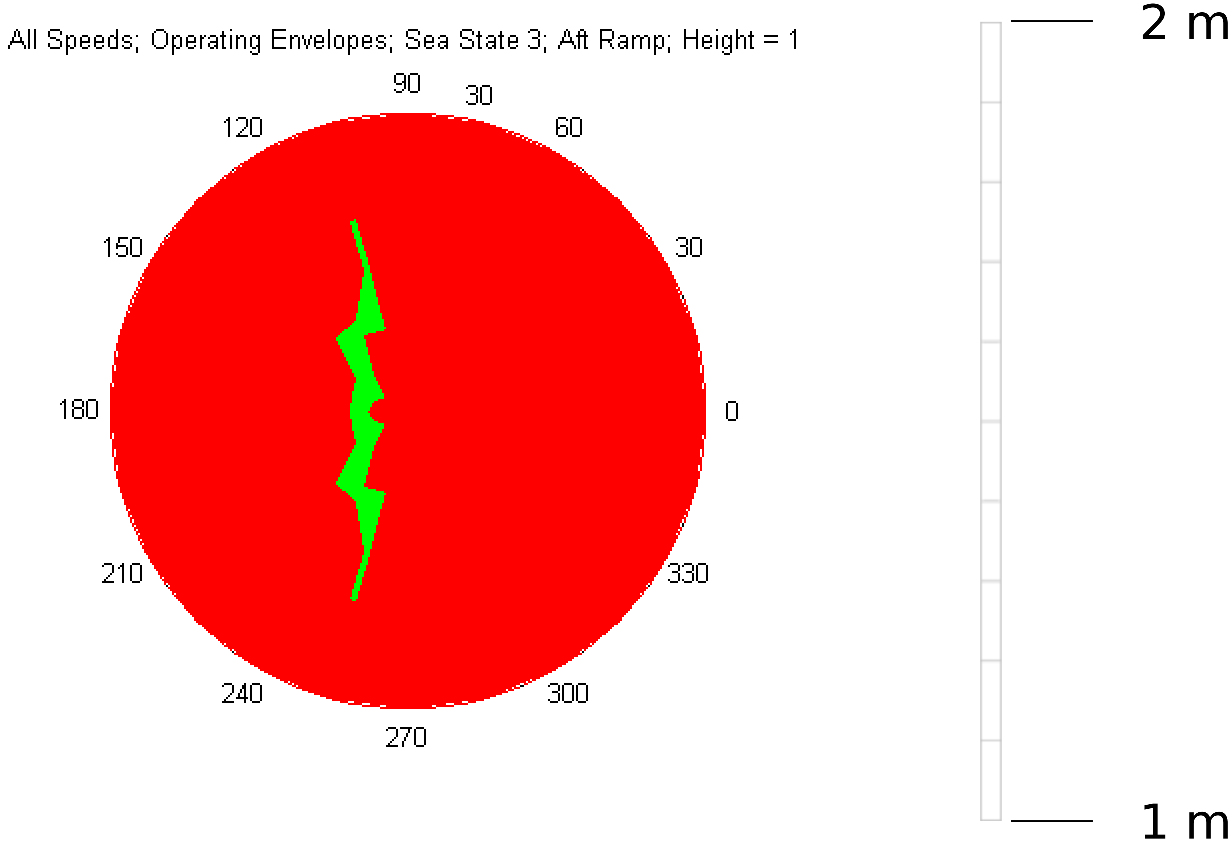
Operating Envelope



Operations can be sustained

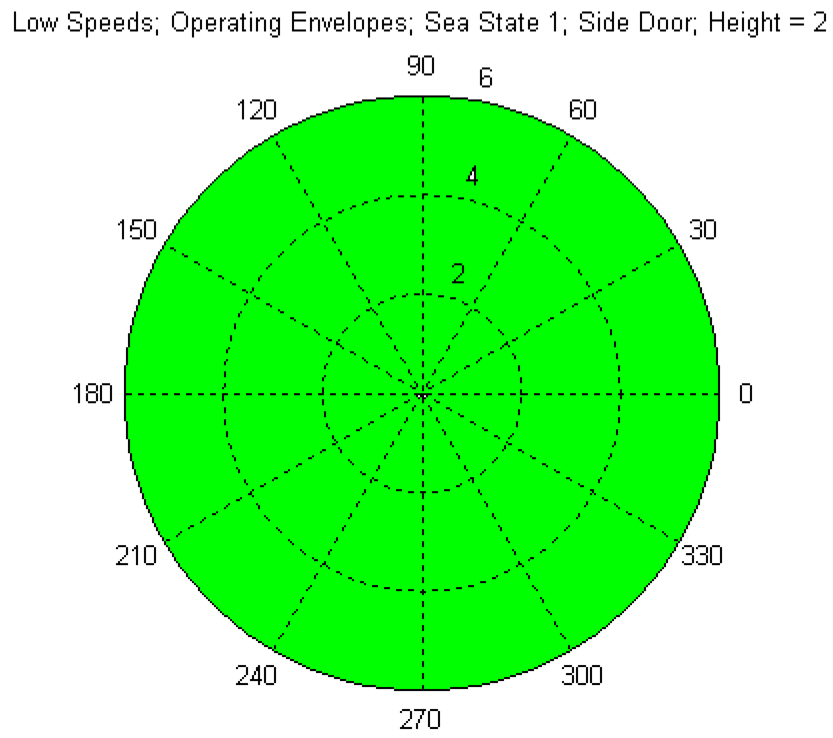
Operations are unsafe

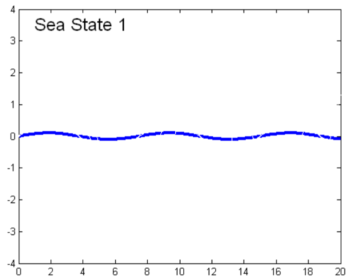
Design Selection



Ramp height at 2 m above calm waterline provides adequate operability region

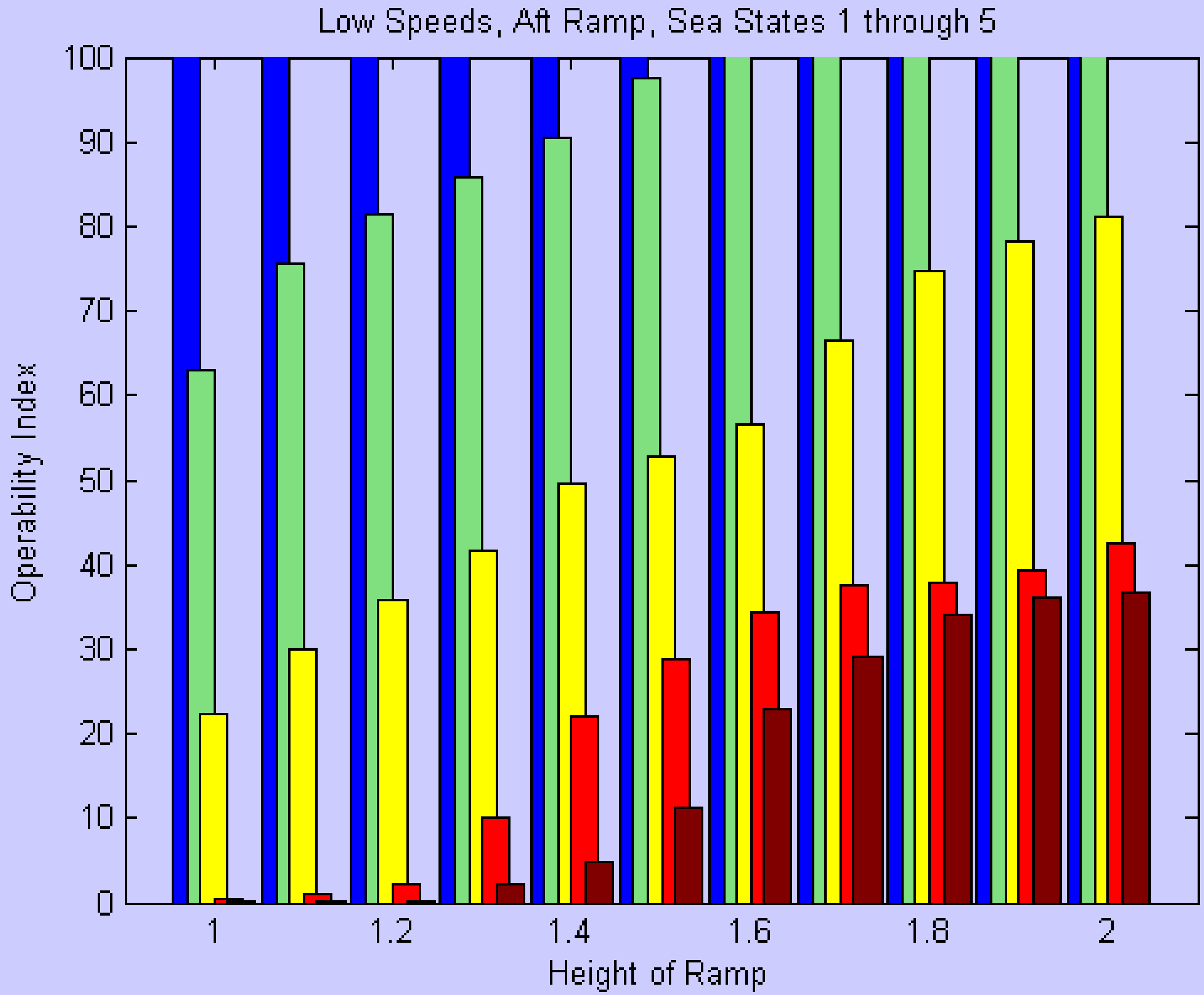
Sea State Effects





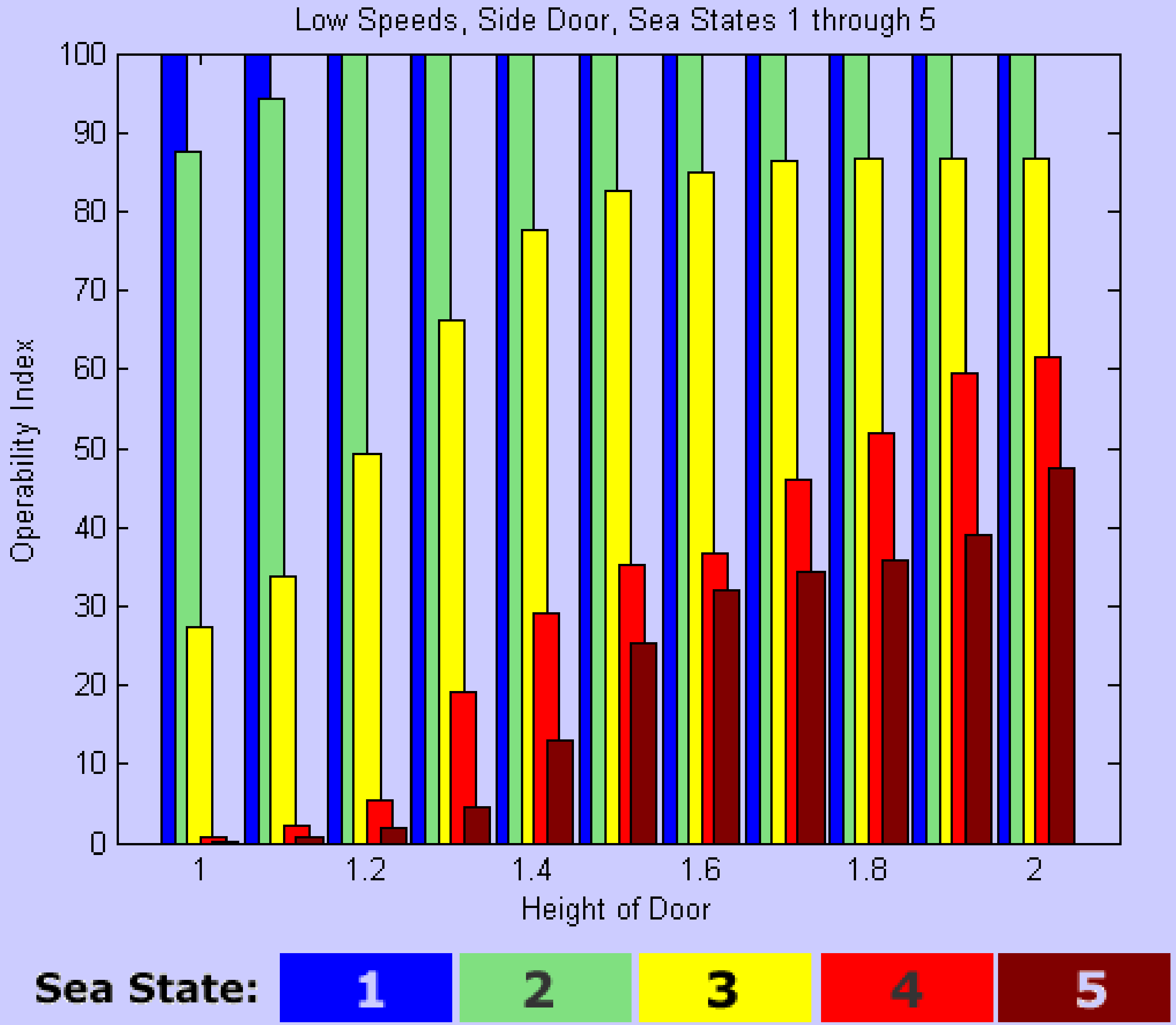
2 m clearance provides adequate operating envelope even for elevated sea states

Operability Index – Aft Ramp



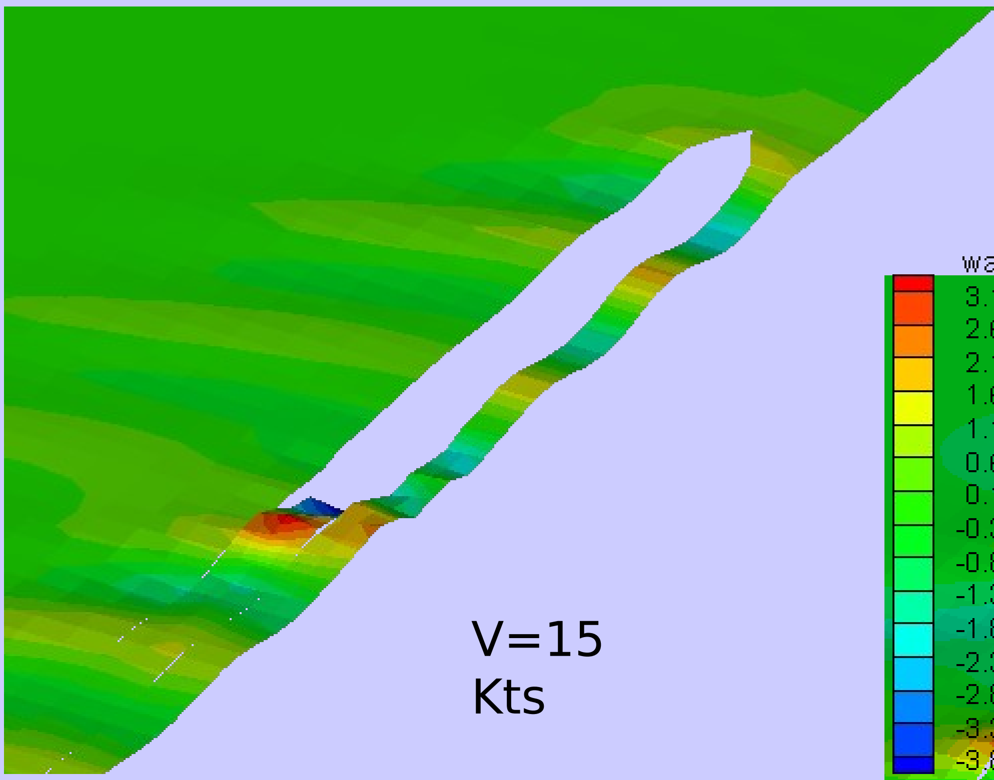
Sea State: 1 2 3 4 5

Operability Index – Side Door

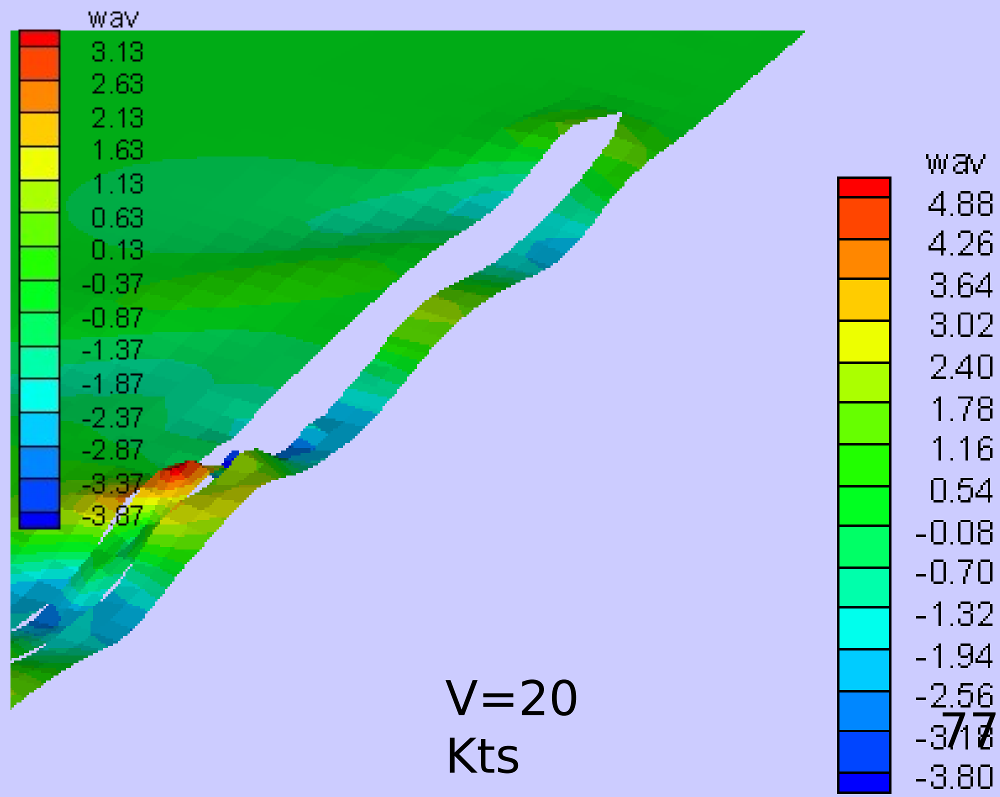


Wave Generation

Kelvin wave pattern calculated using a 3-D panel method



V=15 Kts



V=20 Kts

Agenda

- ✓ Introduction and Overall Design Process
- ✓ Payload and Operational Concept
- ✓ Combat Systems
- ✓ Hull, Mechanical, and Electrical (HM&E)
- Summary
  - Manning
  - Cost
  - Geographical Transit Ranges
  - Requirements Summary
  - Conclusion

Manning

- Reduced manning possible concepts studied on DD(X) and TAK-E(X):
  - Human Centered Design and Reasoning Systems
  - Reliability and Condition Based Maintenance vs. Preventative Maintenance System (PMS)
  - Automated Damage Control
  - Reduced Watch Stations
  - Self Service Laundry
  - Innovative Messing

Core Watch Stations

WATCH STATION LOCATION	WATCH STATION NAME	NUMBER OF PERSONNEL	SUB - TOTAL
Bridge	**Officer of the Deck (OOD)**	**1**	**3**
	Junior OOD	**1**	
	Quartermaster of the Watch	**1**	
Combat Information Center (CIC)	**Tactical Action Officer**	**1**	**9**
	CIC Supervisor	**1**	
	Air Search Radar Operator	**1**	
	Surface Radar Operator	**1**	
	Sonar Operator	**1**	
	Gun Operator	**1**	
	Missile Operator	**1**	
	Electronic Warfare Operator	**1**	
	Aircraft Controller	**1**	
Engineering	**Engineering Officer of the Watch**	**1**	**1**
		[illegible]	[illegible]

Procurement Cost Estimation Process

- Two methods were used to estimate cost:
  - Top-down method using data from the Congressional Budget Office (CBO), Visibility and Management of Operating and Support Costs (VAMOSC), and others
  - Bottom-up method using detailed weight-based Cost Estimating Relationships (CERs), labor costs, and specialized equipment costs
  - The bottom-up method produced results that were less than 10% lower than the top-down method
  - For brevity, only the top-down method is detailed on the following slides

Platform Comparisons

Ship Class	Type	Displacement (tons)	Crew Size	Armament	Missions	Follow ship procurement cost (FY05 $M)	O&S (FY05 $M)
DD(X)	General-Purpose Destroyer	16,000	130	2 Helo, 2 155-mm AGS, 128 VLS	Land attack, ASW	* 3,200	40.8
DDG-51 (II)	Guided-Missile Destroyer	9,200	340	AEGIS, 2 Helo, 1 5-inch, 96 VLS	Long-range air and missile defense, land attack, open-ocean ASW	1,800	31.2
Sea TENTACLE	Focused-Mission Combatant	7,000	100	2 Helo, 2 Millenium gun, 16 VLS, AMRFS, UUV, USV, UAV launch/recover and support	Littoral and open-ocean ASW, maritime interception	* 900	15.9
FFG(X)	Guided-Missile Frigate	6,000	120	2 Helo, 5-inch gun, 48 VLS	Convoy escort, maritime interception, open-ocean ASW	* 700	UNK
FFG-7	Guided-Missile Frigate	4,100	221	2 Helo, 1 76-mm gun, 6 Torpedo Tube	Convoy escort, maritime interception, open-ocean ASW	300	26.1

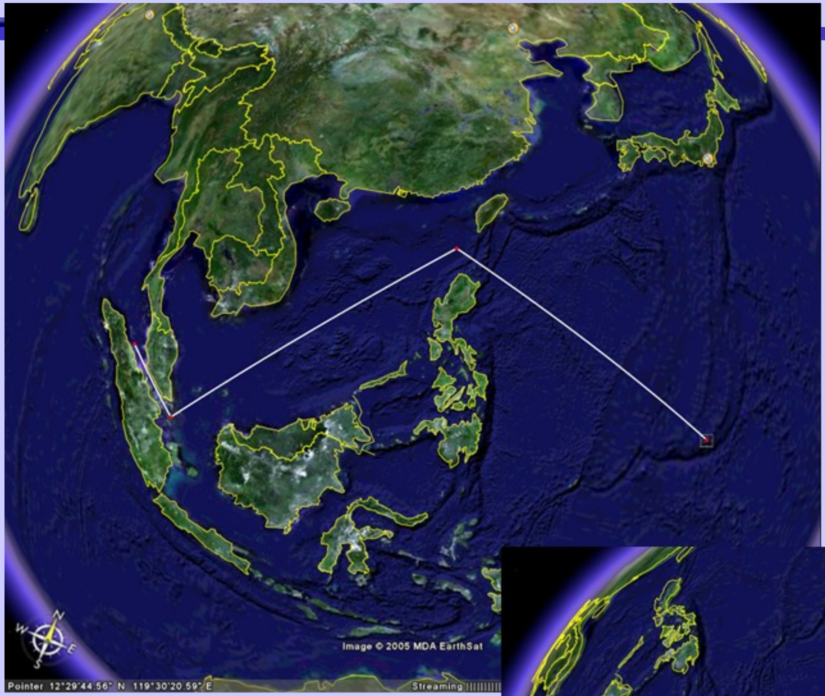
Courtesy of Congressional Budget Office, Congressional Research Service, VAMOSC and Northrup Grumman

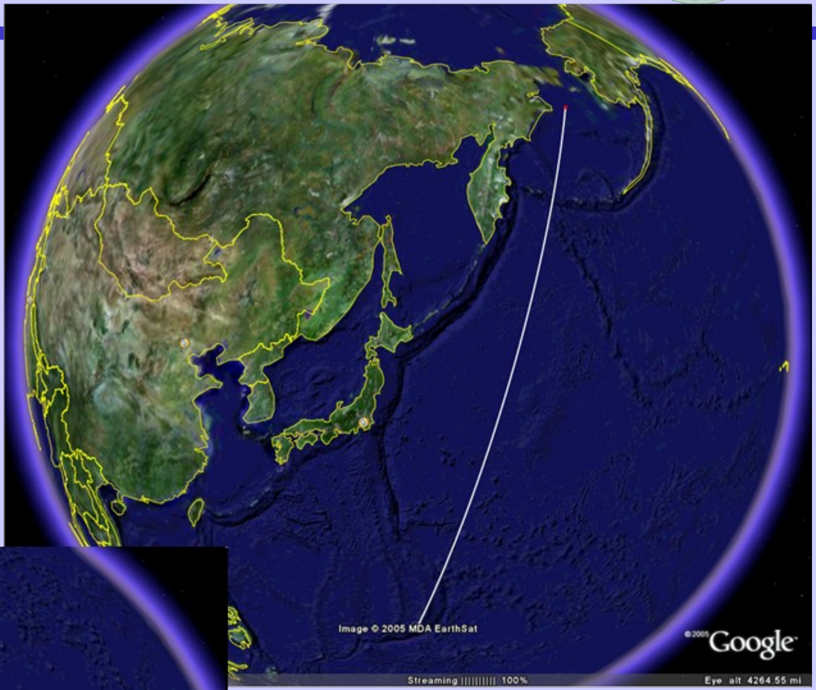
Lead Ship Cost Estimate

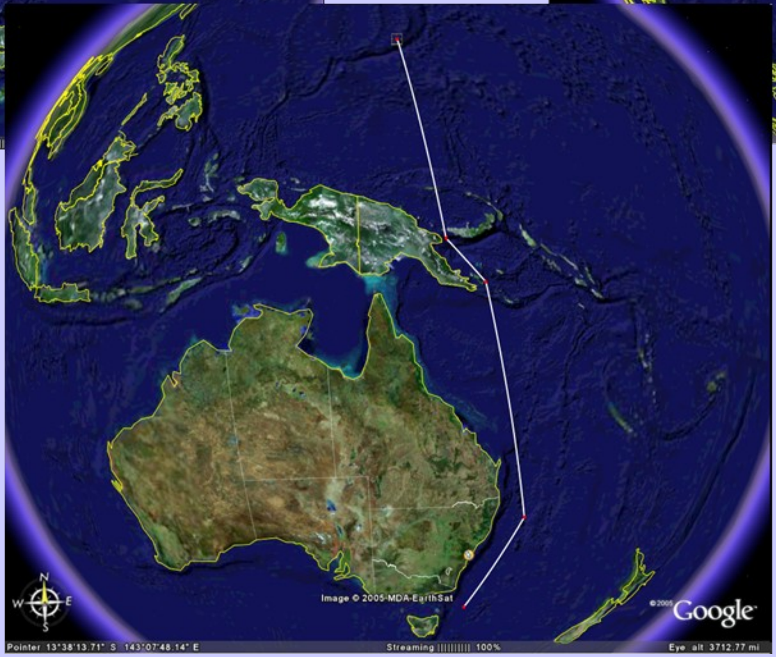
(in millions of 2005 dollars)	Estimated Cost	Primary Basis of Estimate
Detail Design	200	FFG(X)/LCS Analogies
Infrastructure Upgrade	250	Catamaran Hull Construction
Production Costs:		
Basic Construction	990	FFG(X) Analogy
VLS	16	FFG(X) Analogy
Advanced Combat Systems Suite	200	AMFRS
Catamaran Construction	100	
Total Lead Ship Cost	~1,750	

Figures courtesy of Congressional Budget Office assuming 3% inflation rate

Guam 10-day Striking Range

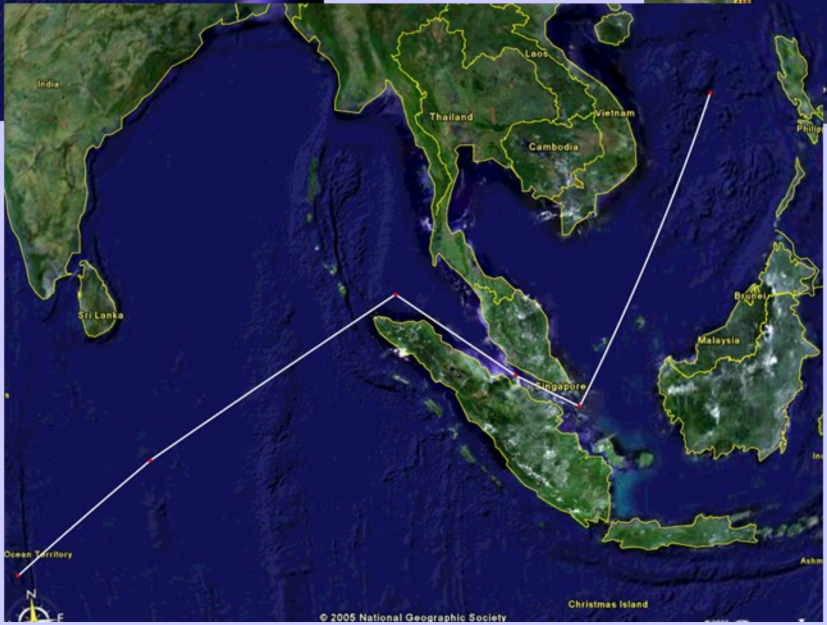






3400 nm

Diego Garcia 10-day Striking Range



3400 nm

Sasebo 3-day Striking Range

1000 nm

Arabian Gulf 3-day Striking Range

1000 nm

Critical Design Parameter Results

Category	Threshold	Objective	Actual
Operational Availability	0.85	0.95	N/A
Hull Service Life	20 years	30 years	N/A
Draft @ Full Load	8 m	5 m	5.1 m
Max Speed	30 + kts	40 + kts	40 kts
Range @ Max Speed	1000 nm	1500 nm	920 nm (1045 nm @ 35 kts)
Range @ Cruise Speed	3500 nm	4500 nm	5400 nm (20 kts)
Large UUV Capacity	40	50+	50 (48 SP, 2 WLD-1)
Hvy Wt UUV capacity	80	100+	110
Cargo Weight	400 MT	800 MT	570 MT
Cargo Volume	5000 m^3	6000 m^3	5500 m^3
Small Boat (7 m RHIB)	1	2	2
USV (11 m RHIB)	1	2	2
UUV/USV/UAV Launch Recover	Sea State 3	Sea State 4	Sea State 4
Aviation Support	One 7000 lb VTUAV	VTUAV (2)/ SH-60R	VTUAV (2)/ SH-60R (2)
Aircraft Launch / Recover	VTUAV	VTUAV/SH-60R	VTUAV/SH-60R
UNREP MODES	RAS, CONREP, VERTREP	RAS, CONREP, VERTREP	RAS, CONREP, VERTREP
Core Crew Size	≤130	≤100	Approx 110
Crew Accommodations	125	125	125
Provisions	30 days	45 days	30 days

Top Level Requirements Revisited

Deploy

- **Prepare system components**
- **Deliver system components**
- **Sustain system components**

- ✓ **Deploy, retrieve, and regenerate large UUVs semi-clandestinely**
- ✓ **Sensor assets required to provide Pd 0.8 across contested OA (6,700 NM2) within 10 days**
- ✓ **Provide logistic support necessary to sustain SoS for 30 days**
- ✓ **Communicate on the following circuits:**
  - **High Band Width Air/Space Line of Sight (LOS)**
  - **LOS Data**
  - **LOS Voice**
  - **OTH Data**
  - **OTH Voice**
  - **SATCOM**
  - **Underwater Data**
- ✓ **Launch, recover, and control a 7,000 lb UAV**
- ✓ **Deploy box-launcher weapons and torpedoes for enemy engagement**

Conclusions

- **Employs a large, well designed, and flexible Payload configuration**
- **Combat Systems offer a robust mix of Offensive and Defensive capabilities that can conduct simultaneous ASW, SUW, & AAW operations**
- **HM&E design delivers high speed & high power in a unique and efficient manner**

Sea TENTACLE is the platform of choice for Littoral ASW in 2025